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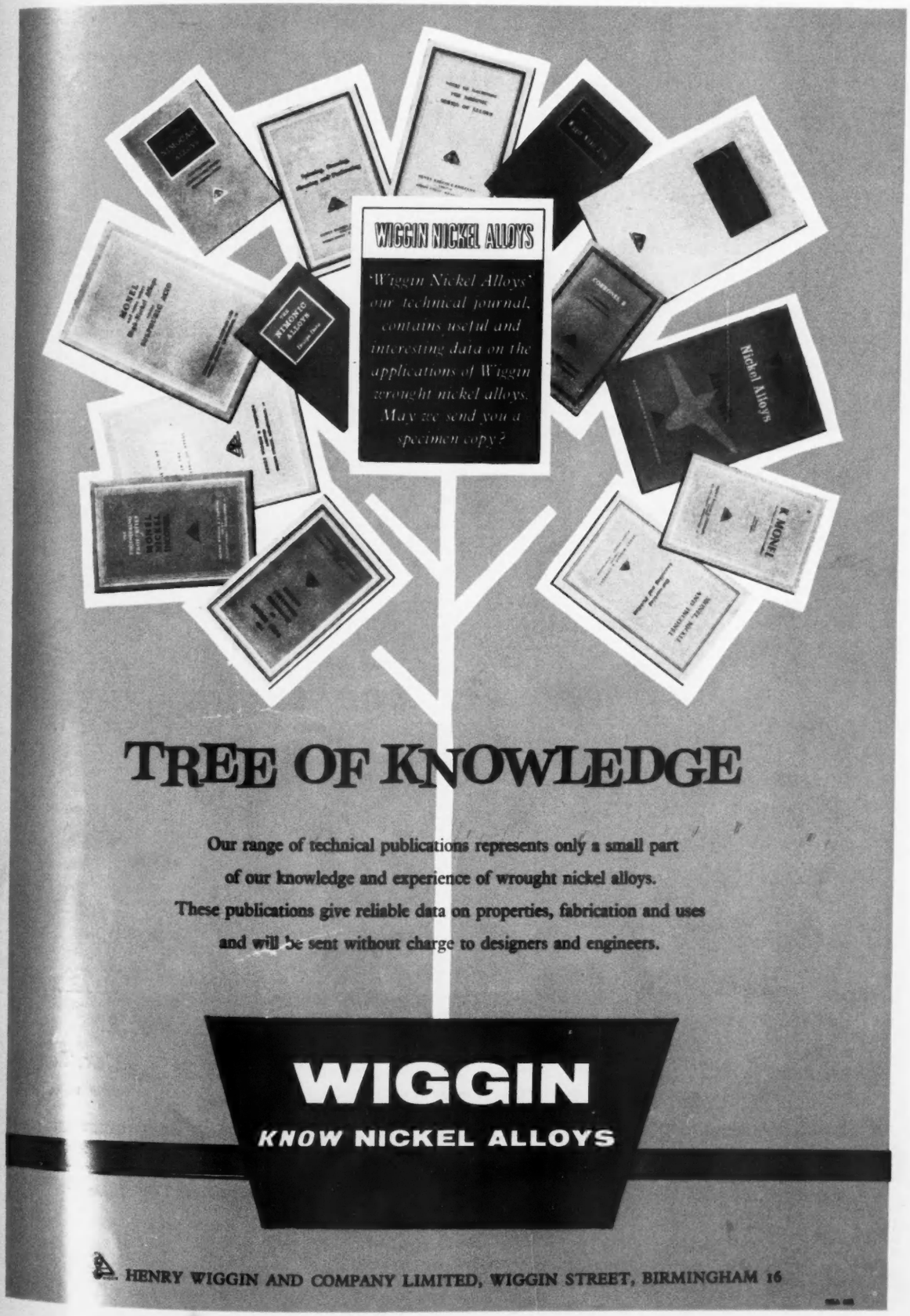
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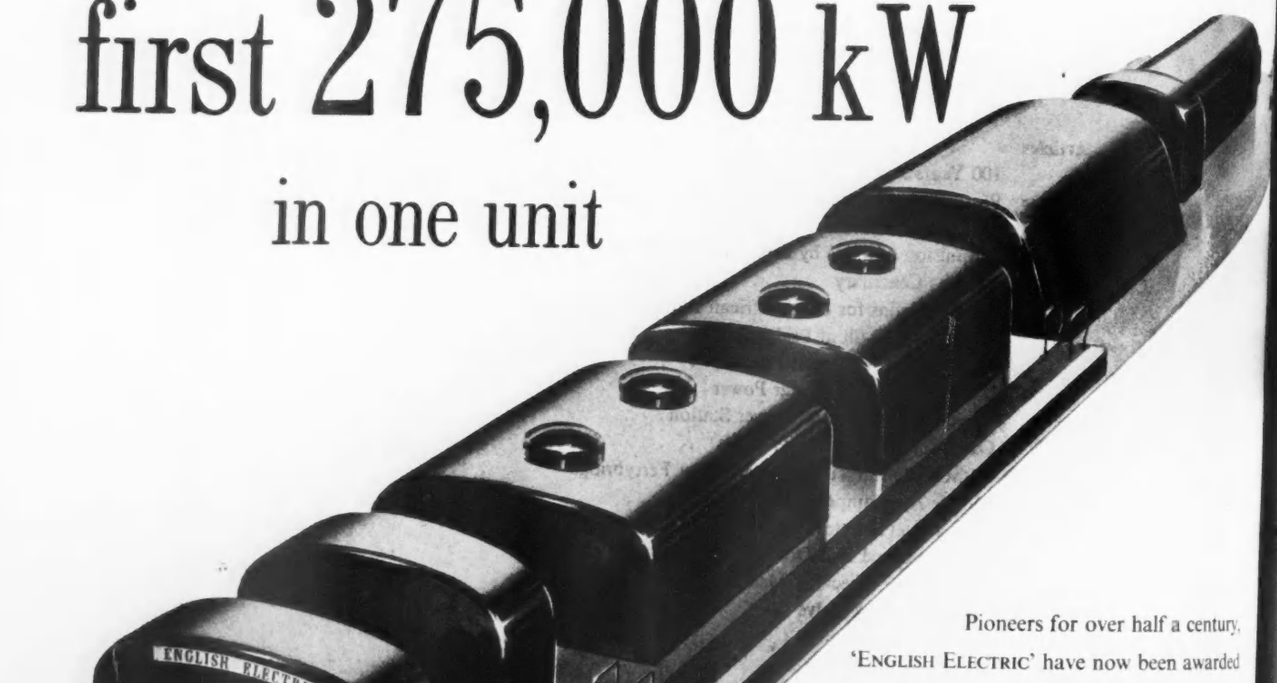

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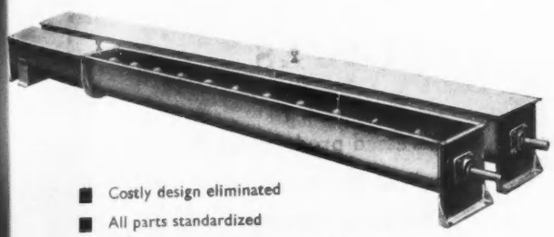

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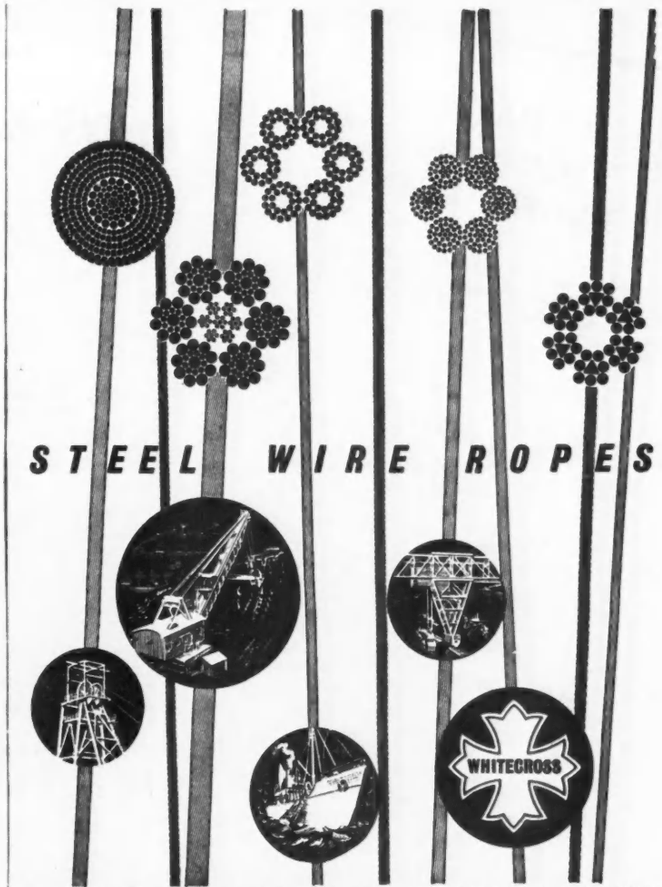

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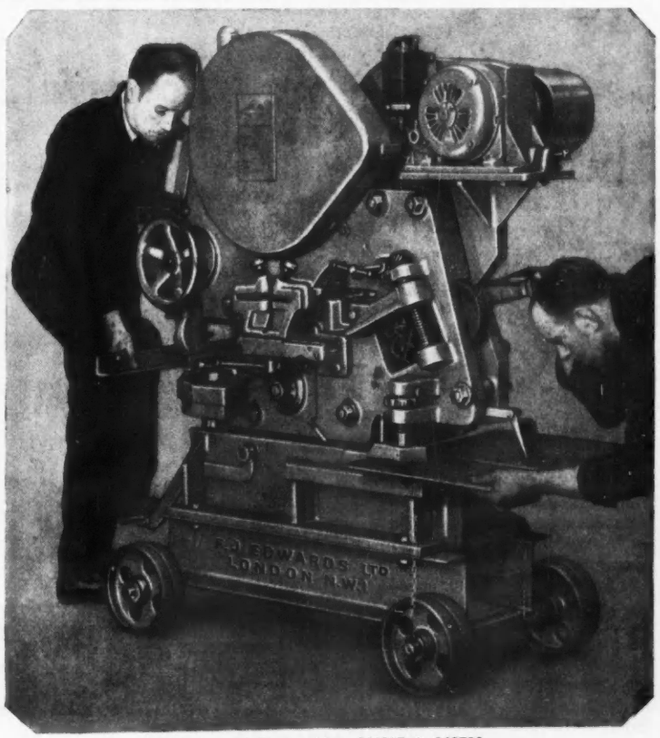

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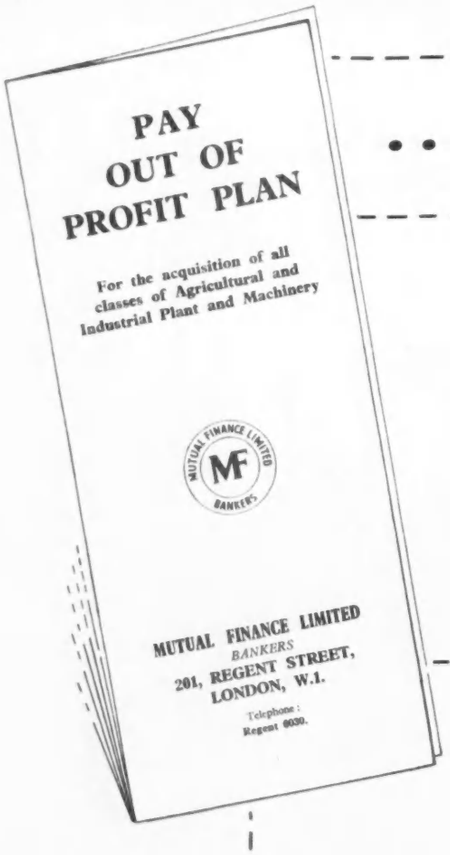

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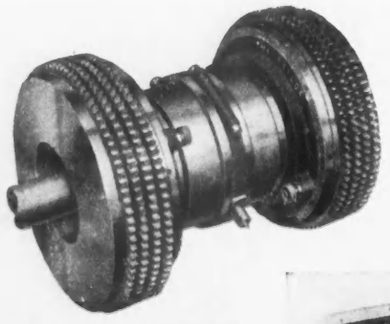

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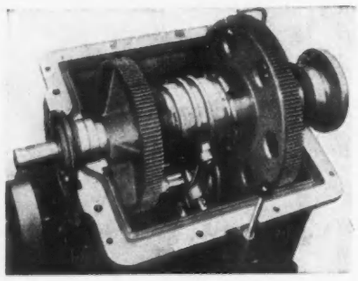

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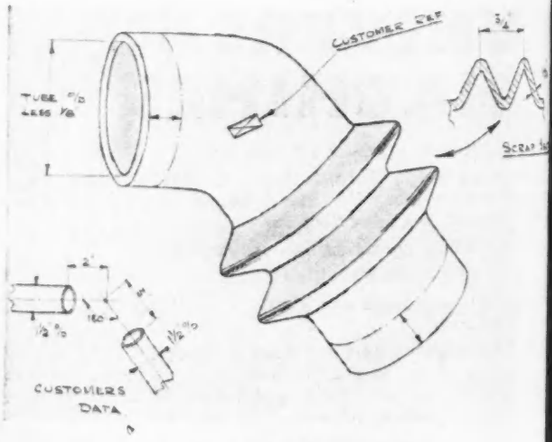

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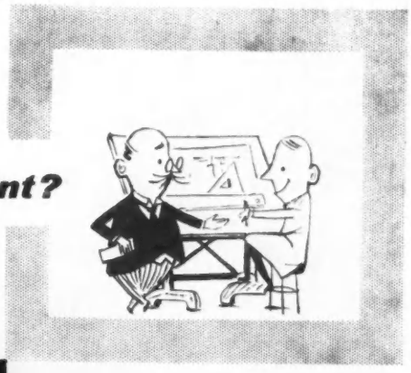

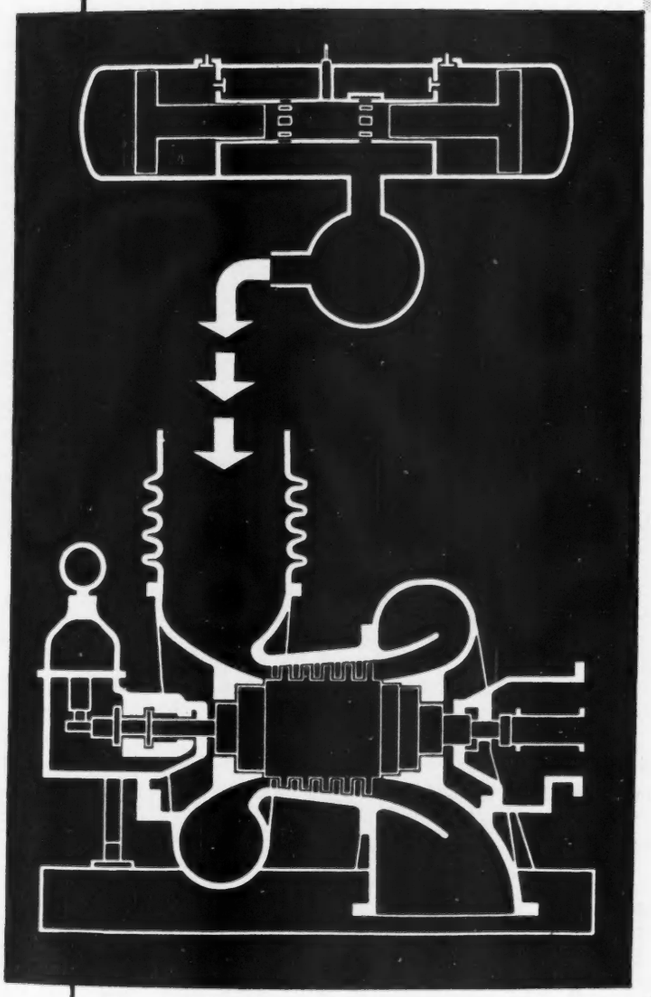

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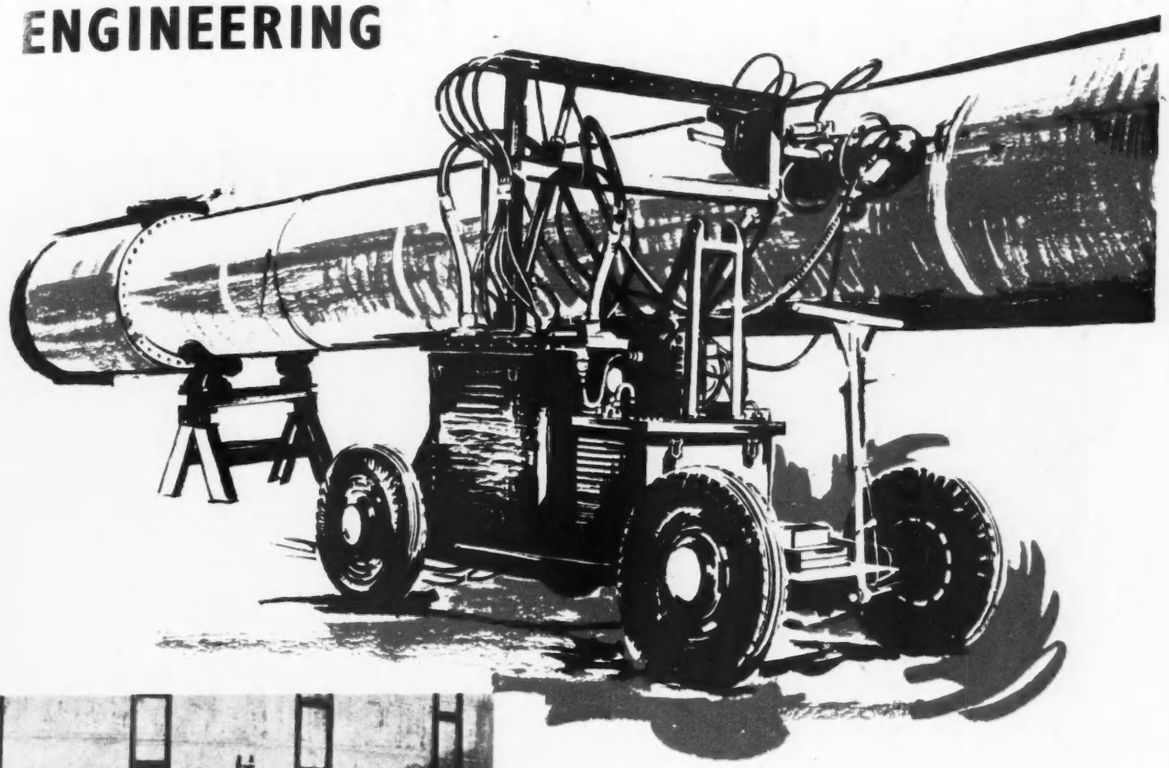

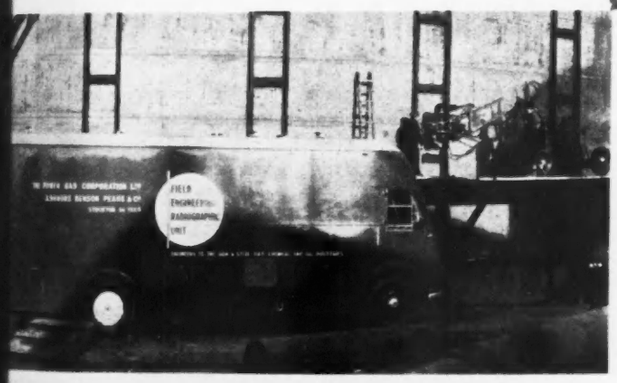

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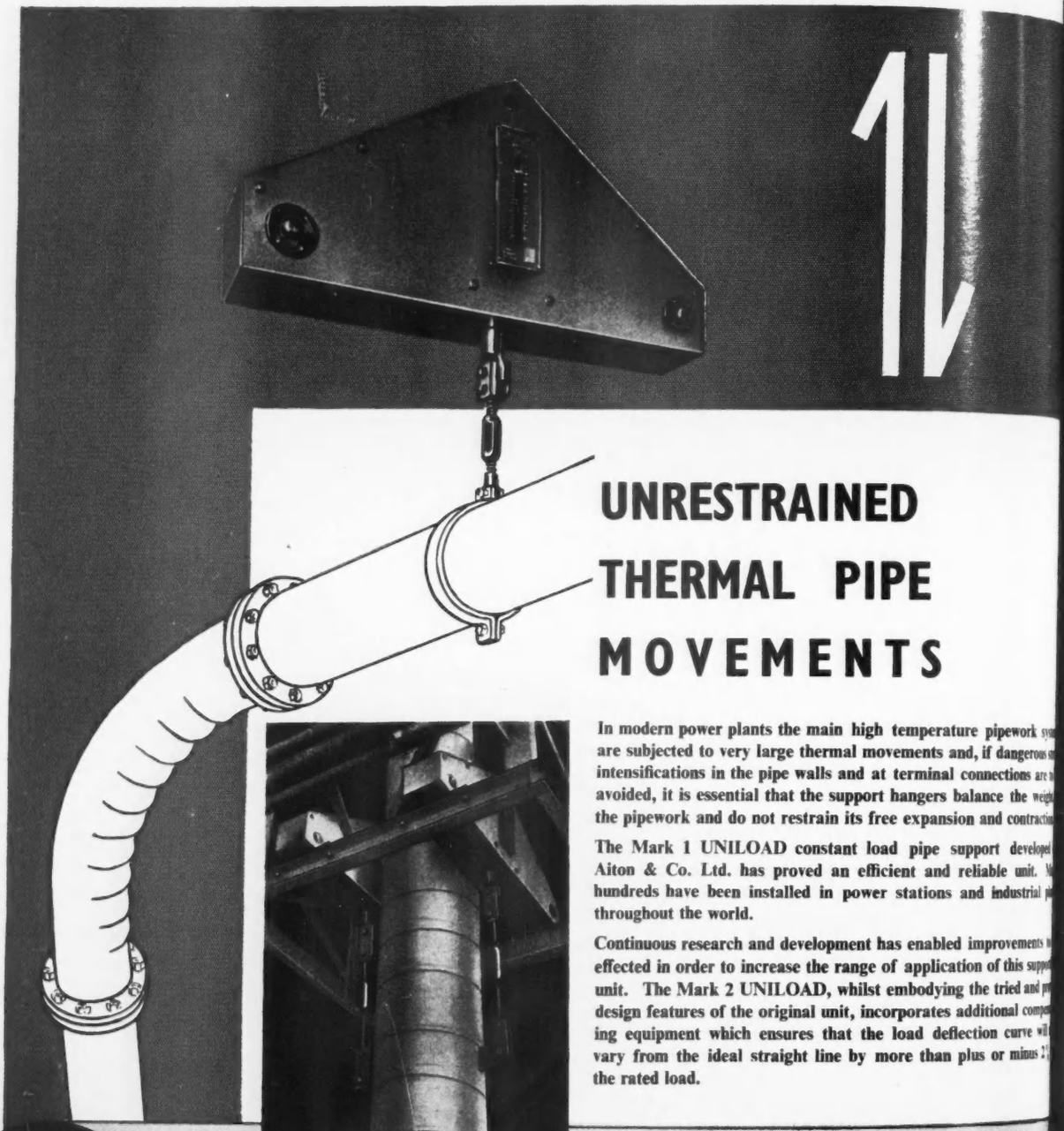

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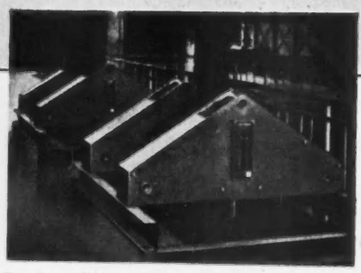

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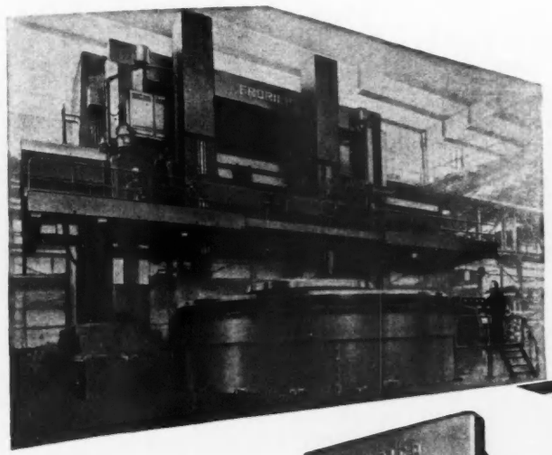

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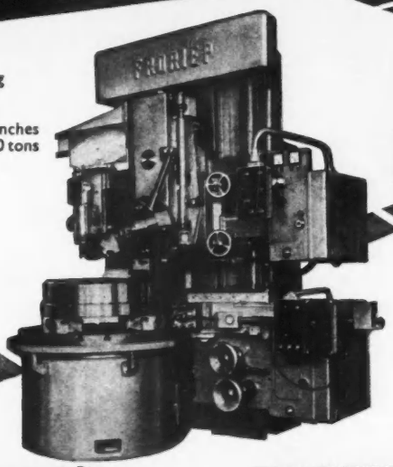

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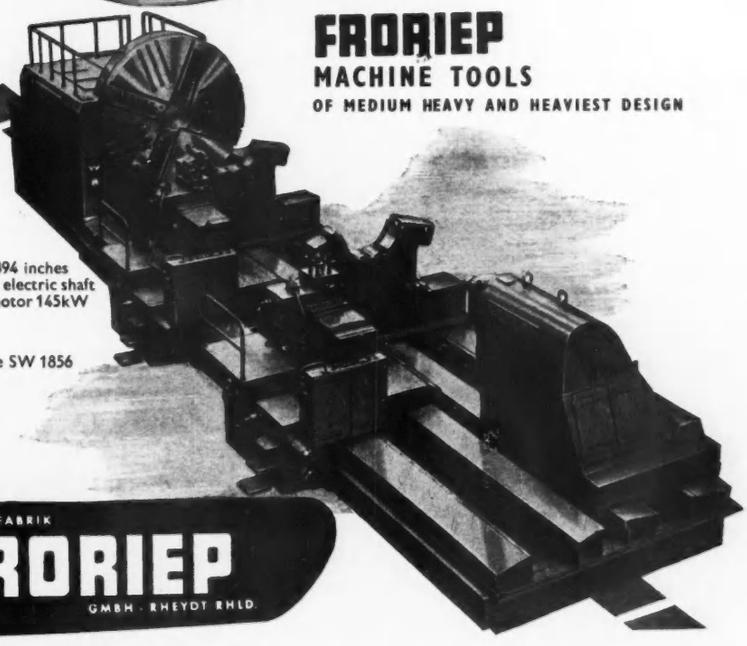

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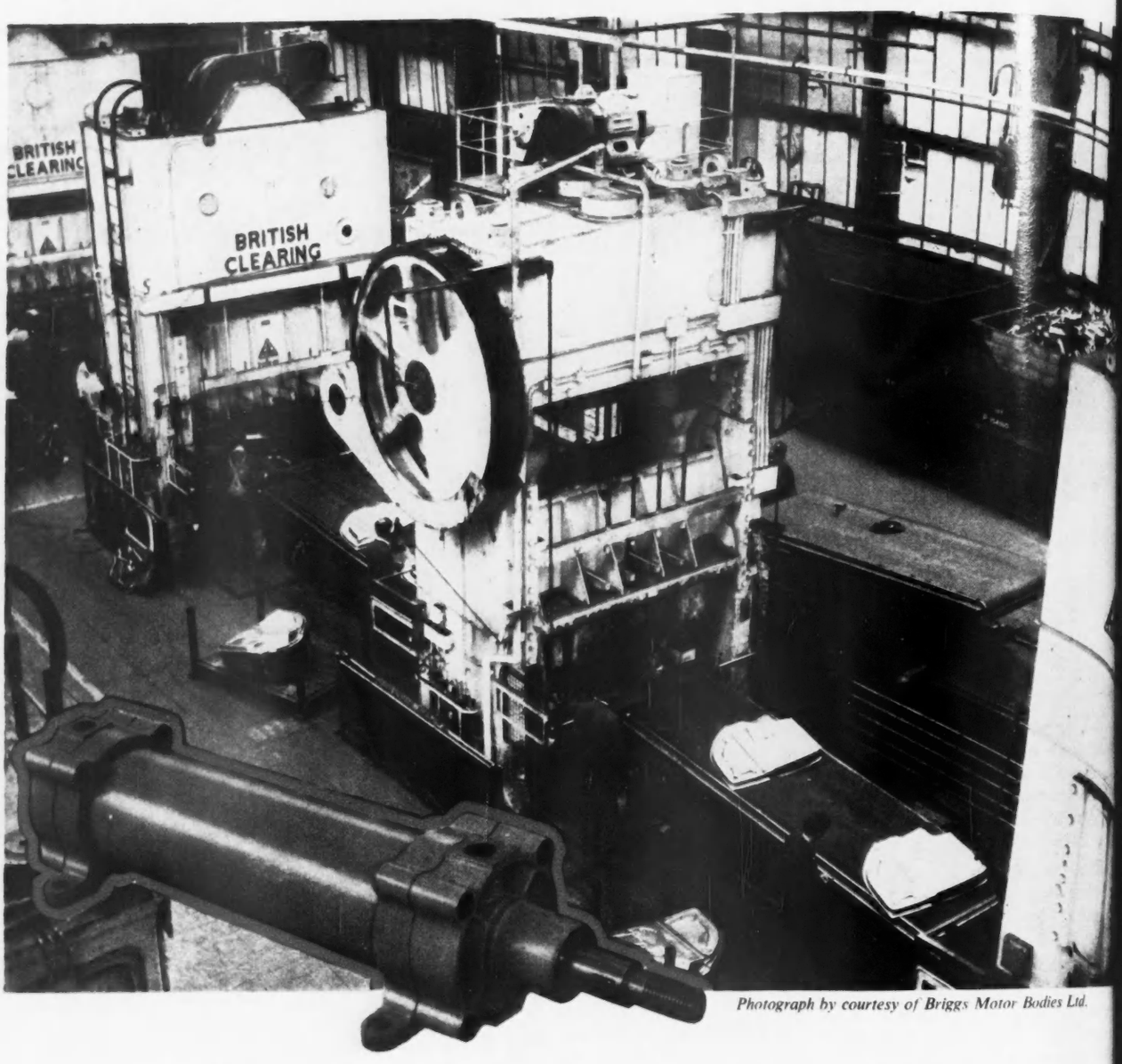

Photograph by courtesy of Briggs Motor Bodies Ltd.

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The air cylinders supplied by Baldwin Instrument Co. Ltd., to provide power operation for automatic work handling devices, have 'Fescol'-ised bores and piston rods to reduce friction and ensure maximum life from seals. This is one further example of the way in which Fescol, who pioneered the electro-deposition of nickel and chrome for engineering purposes, still lead the way, adapting their process to help each new industrial development.

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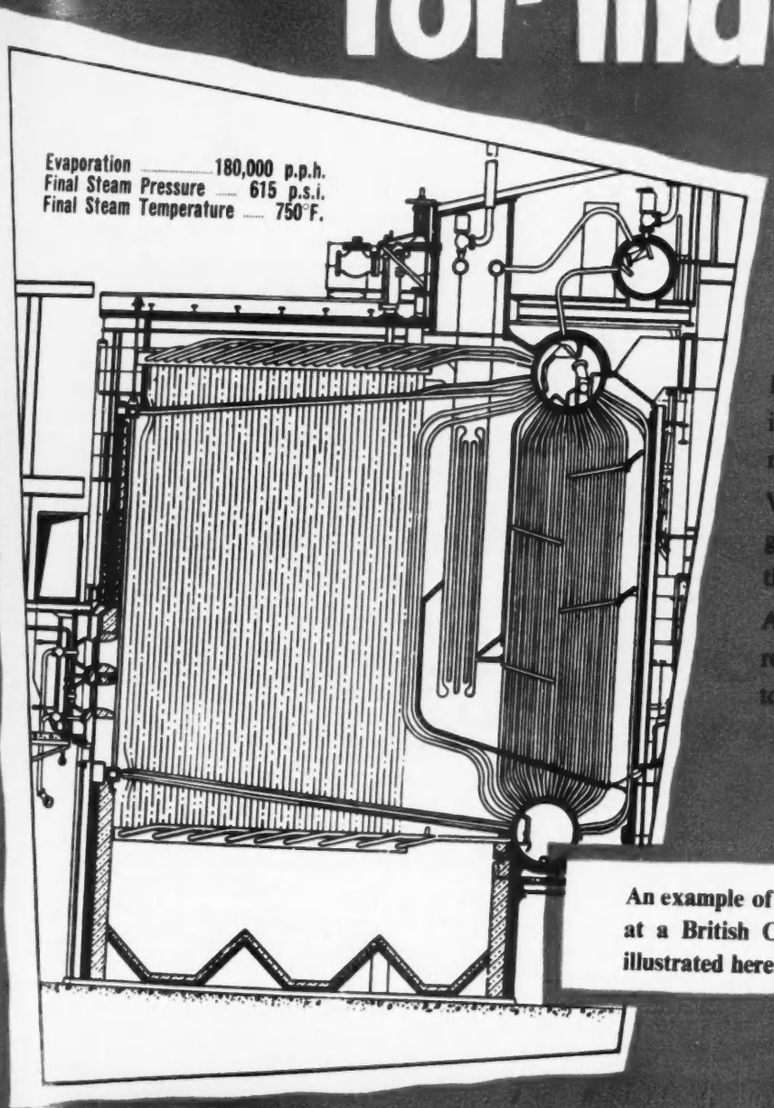

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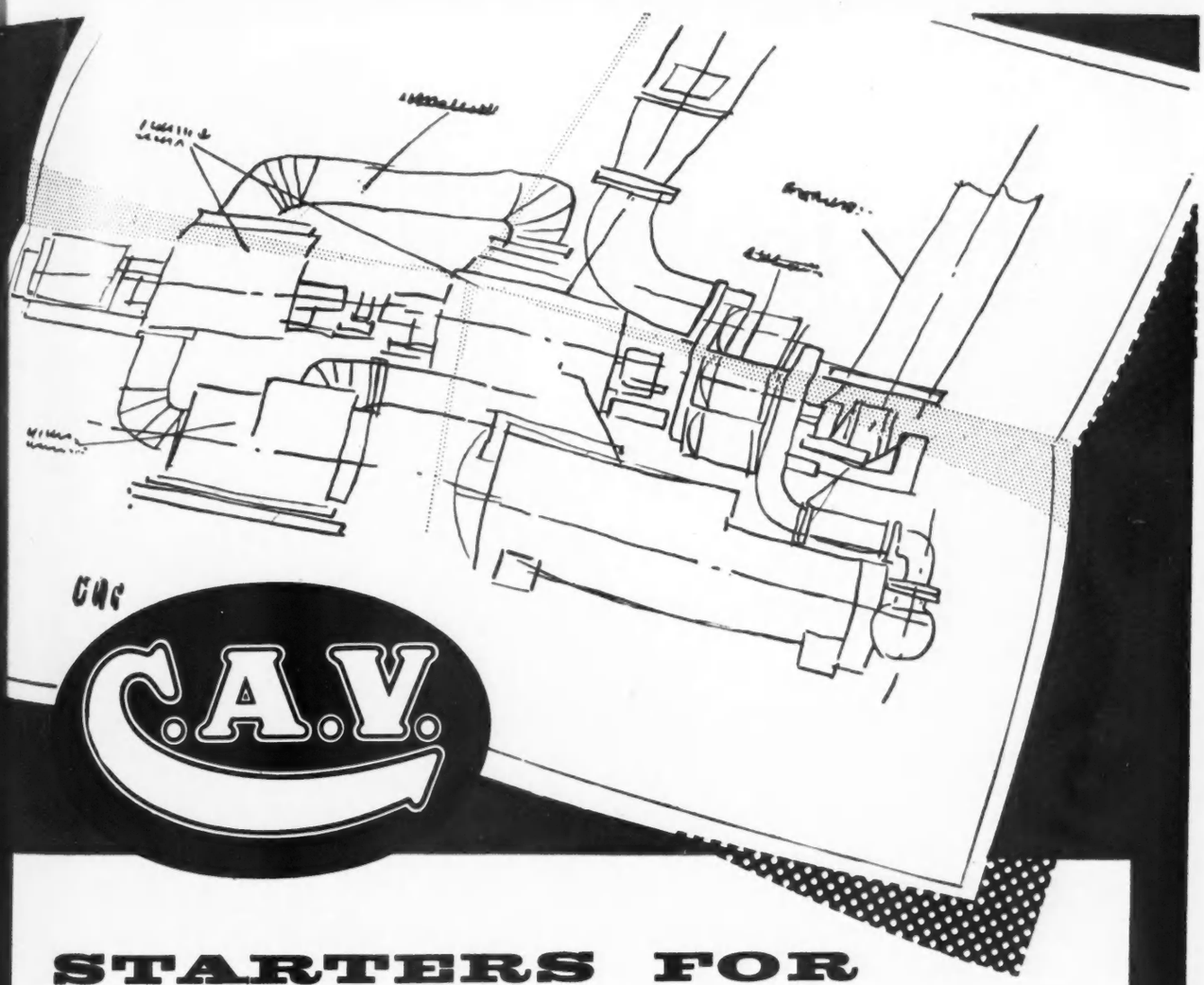

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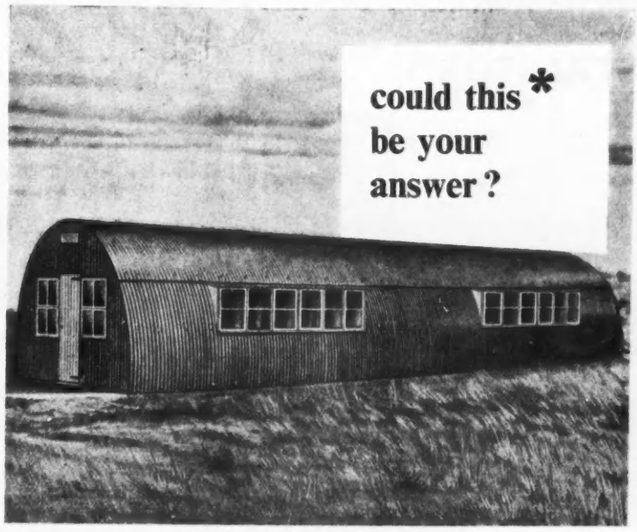

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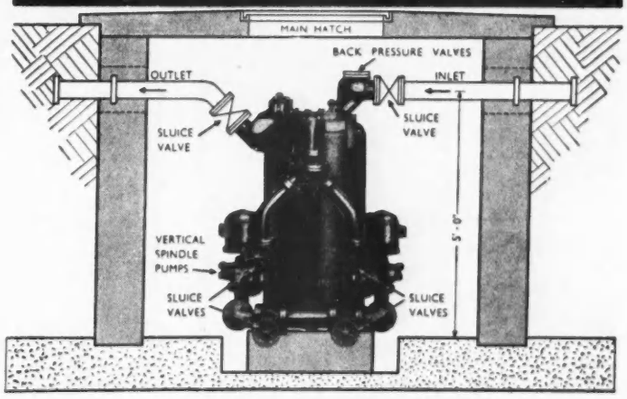

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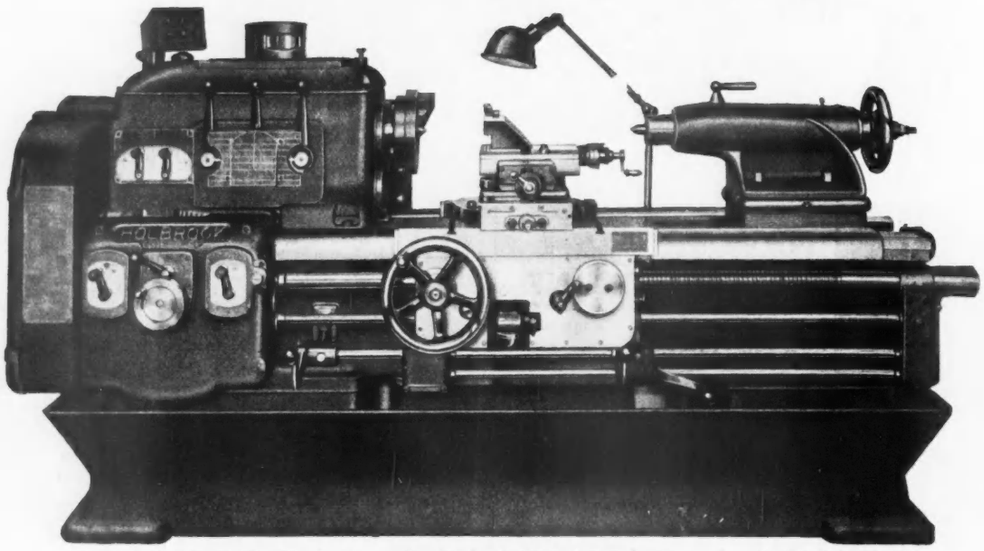

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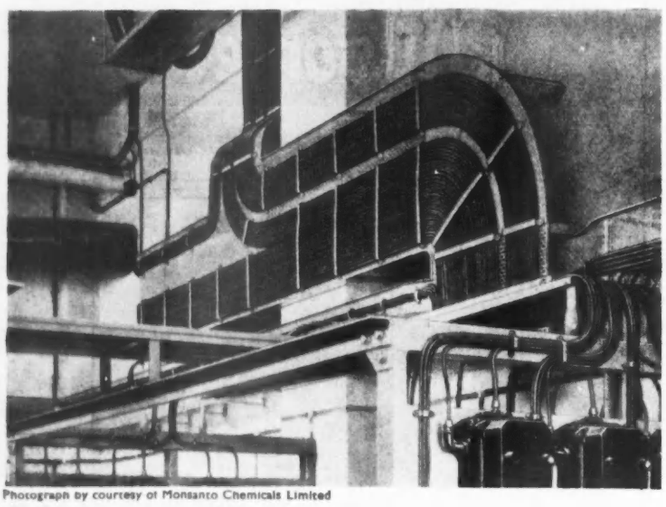

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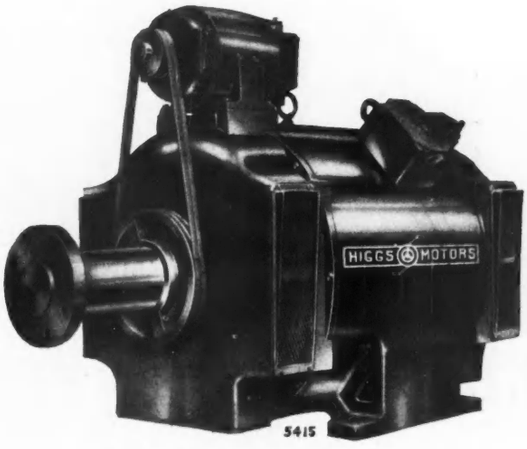

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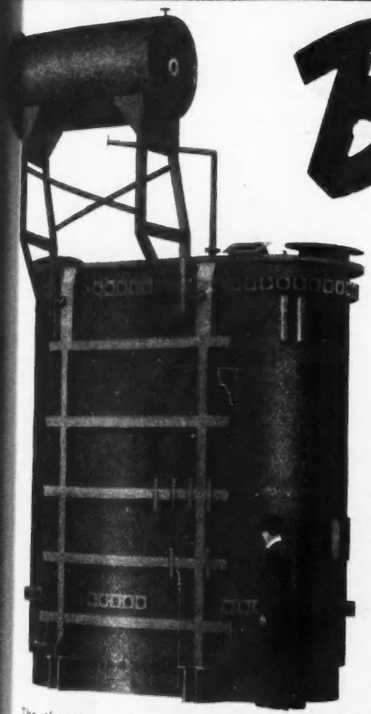

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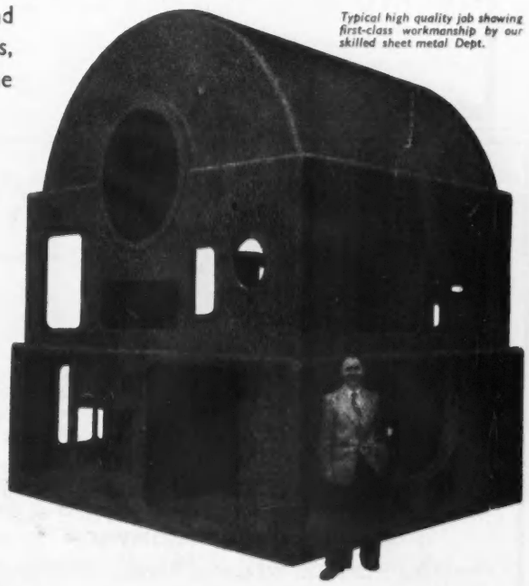

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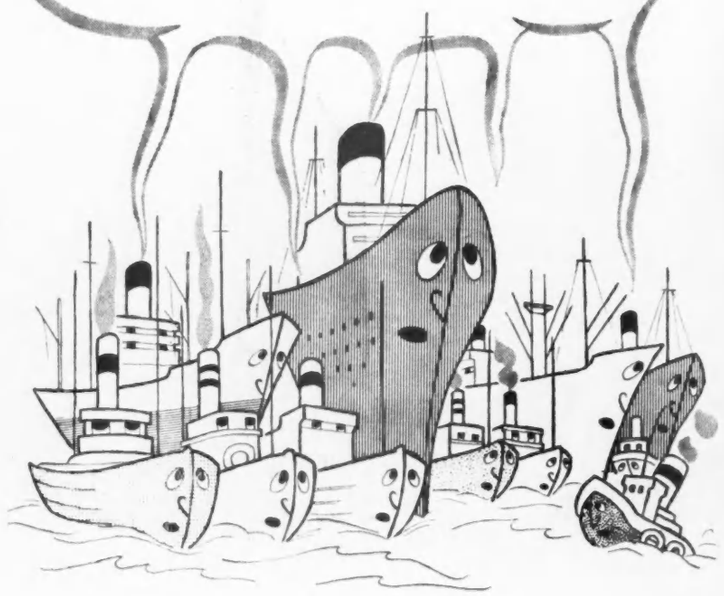

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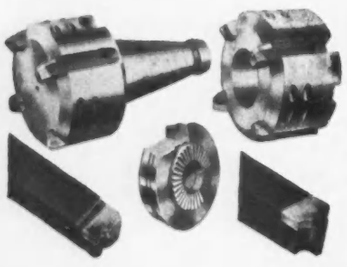

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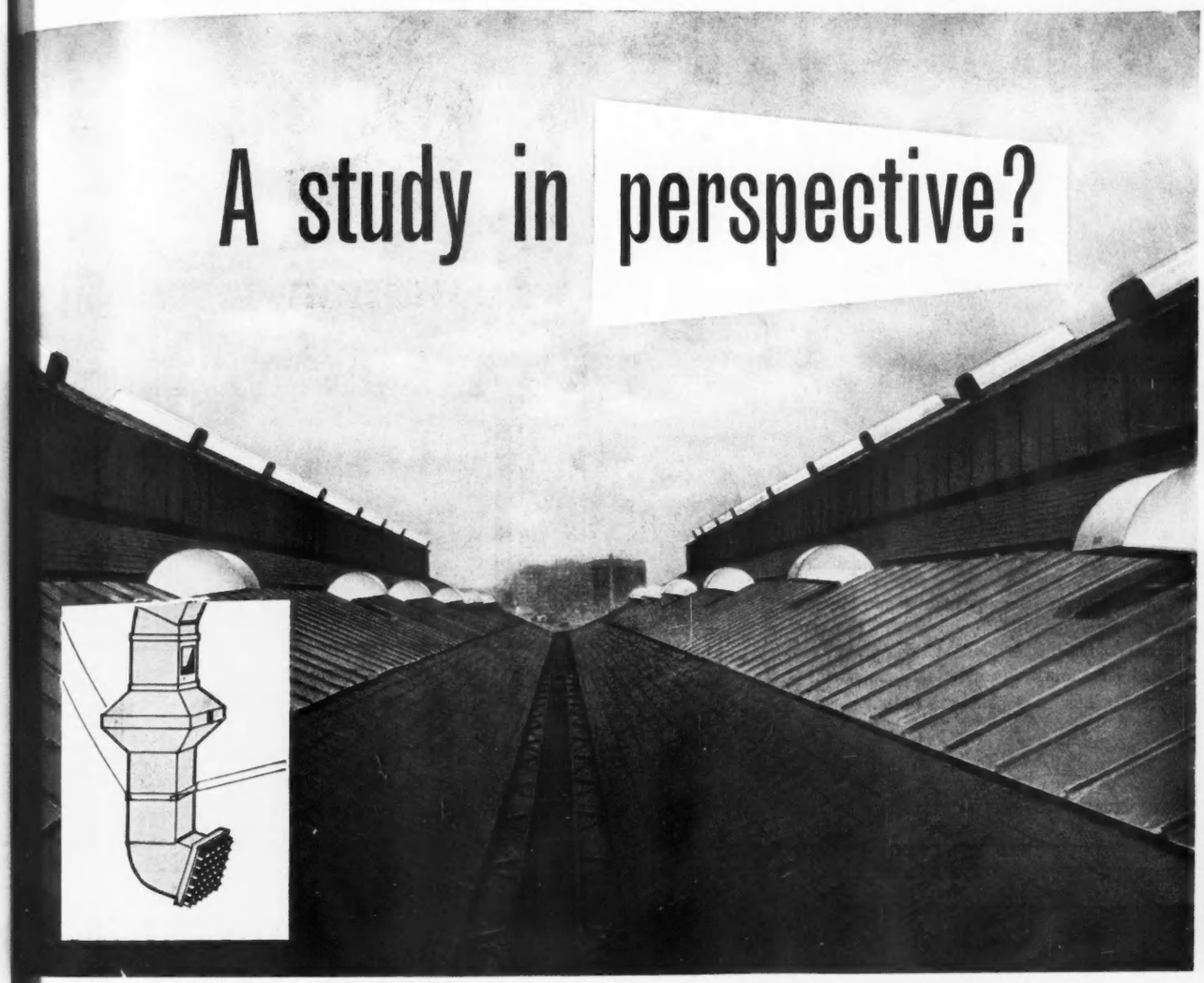

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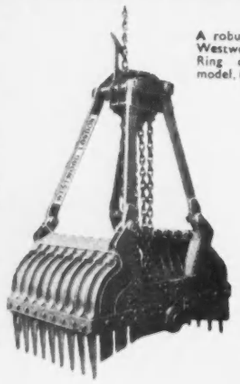

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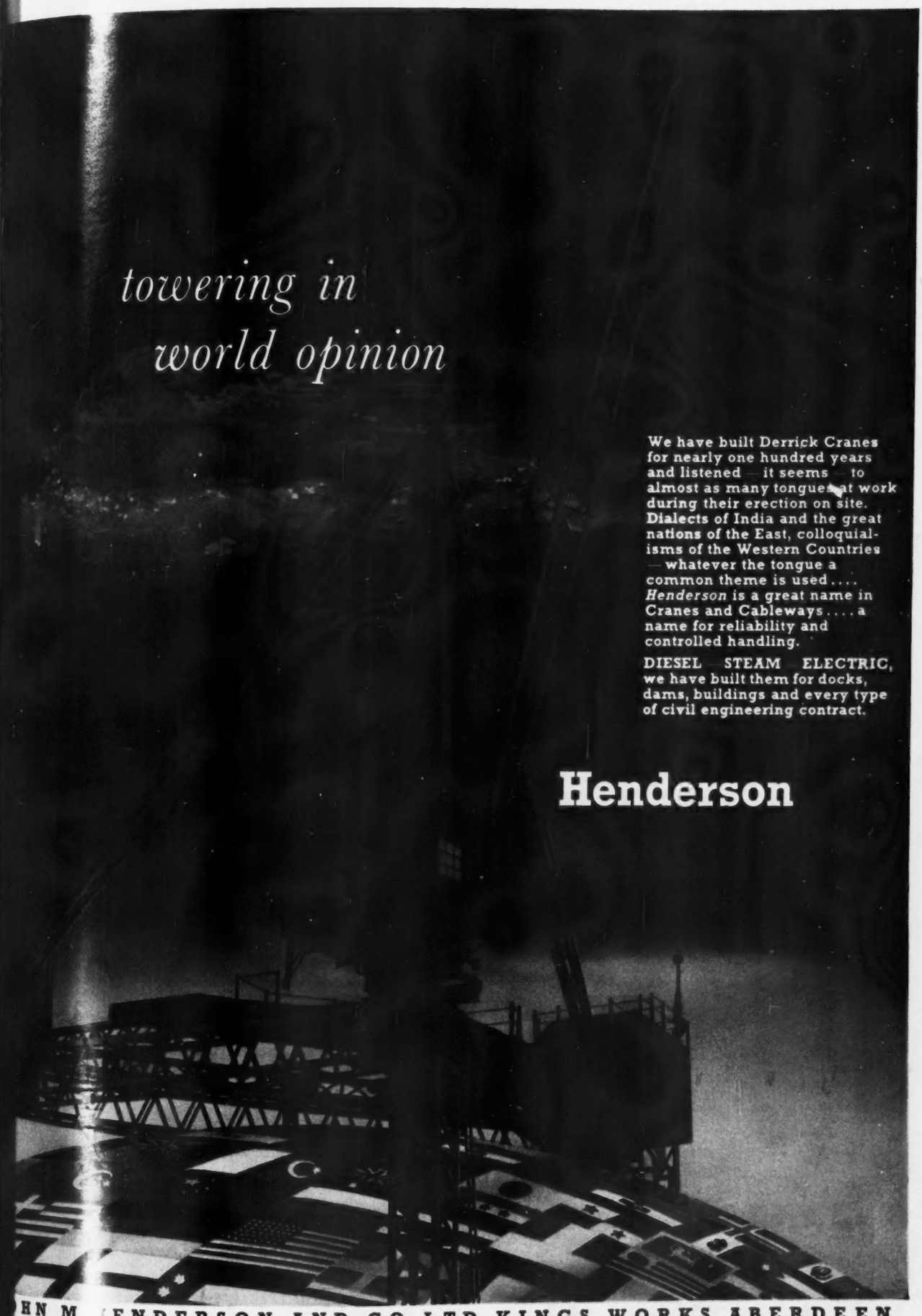
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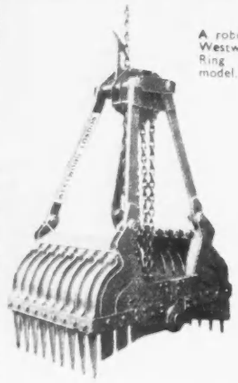

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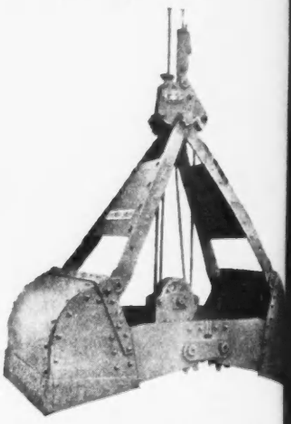

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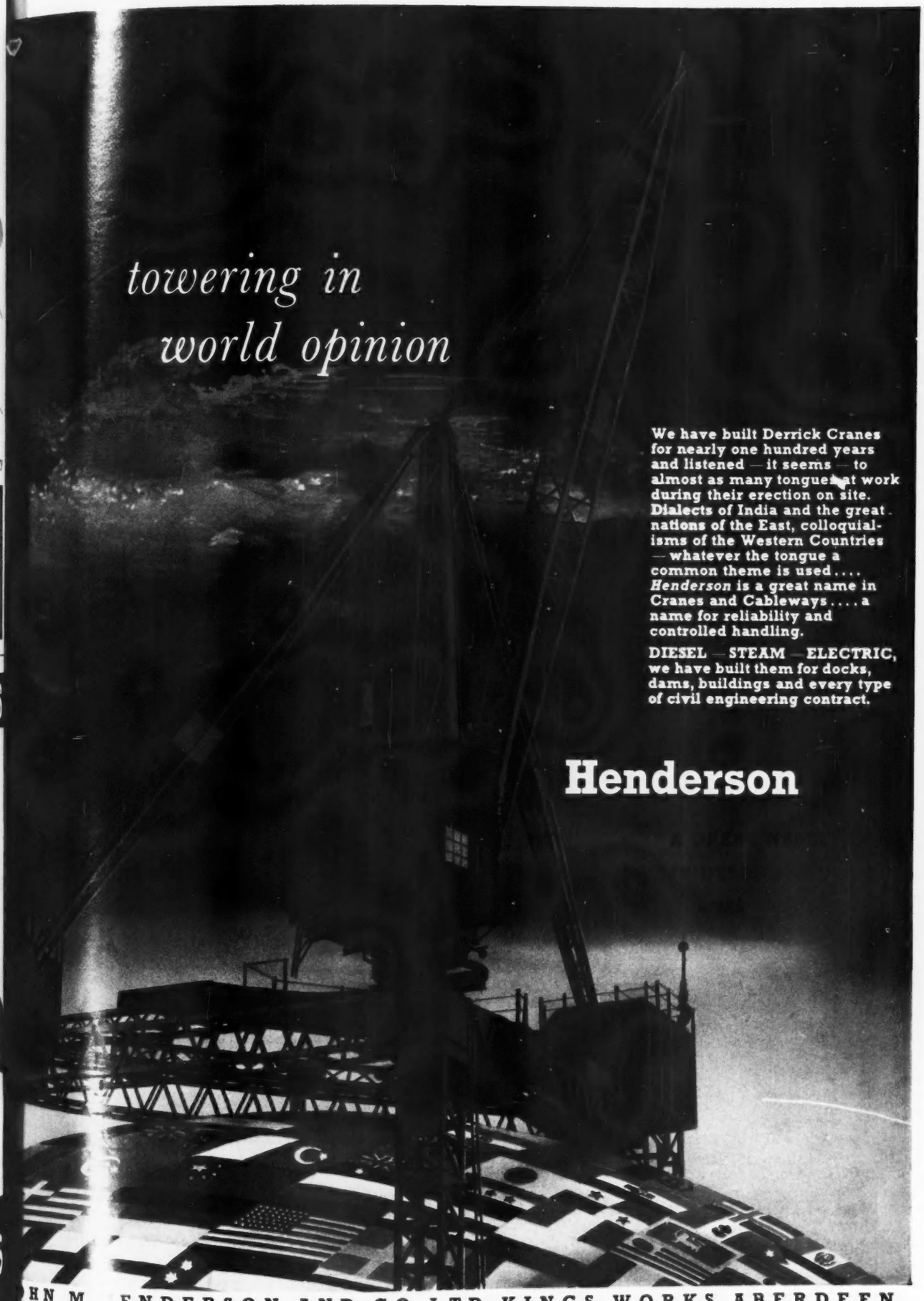

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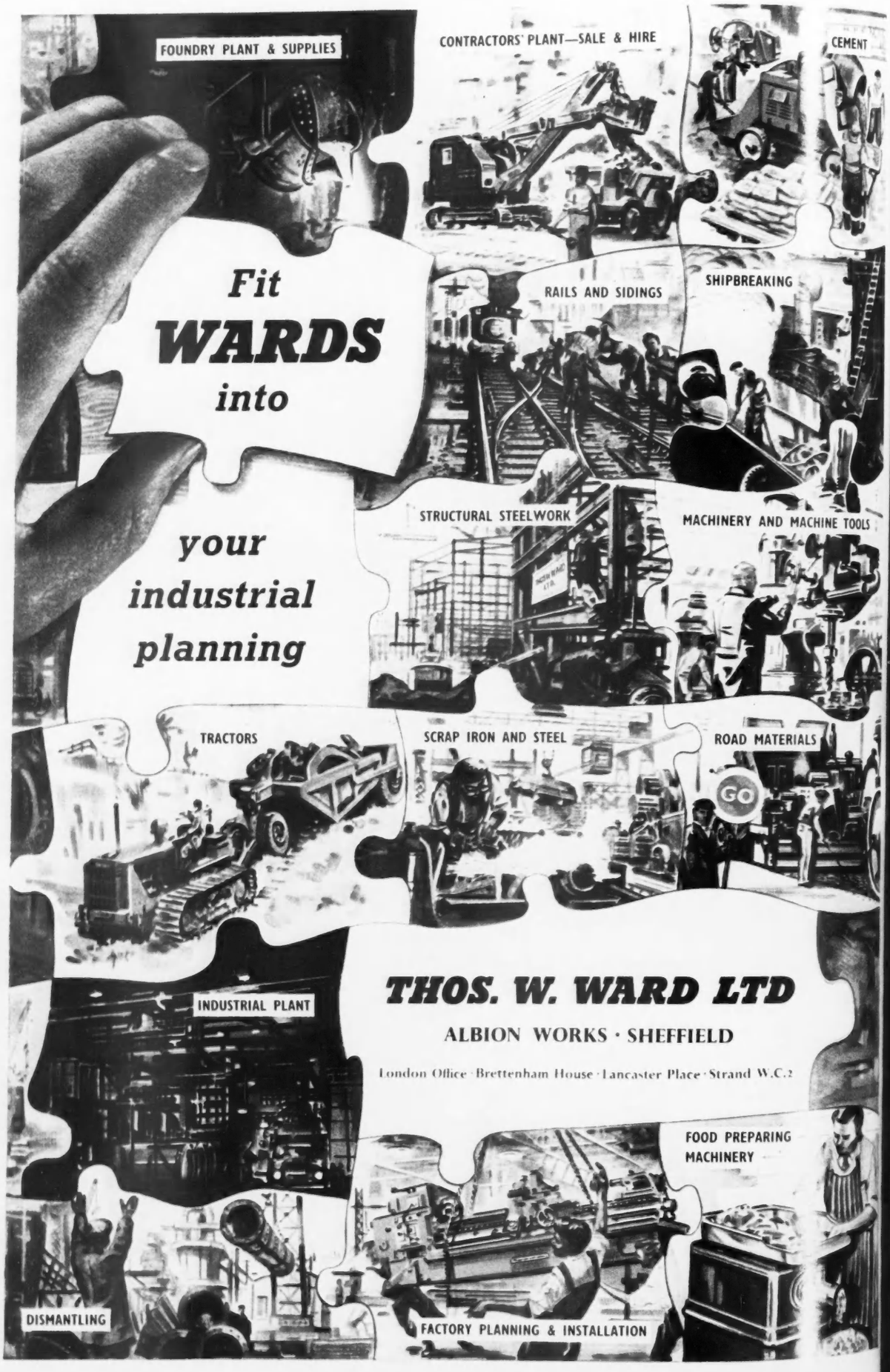
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Molybdenum Disulphide greases are now being employed by all sections of British industry to overcome serious lubrication problems associated with extreme pressures, fretting corrosion, impact shocks, and arduous working conditions where oscillation and reciprocation are involved. Their use results in substantial reduction of wear, much lower starting torque and greatly improved running. This is clearly demonstrated by analyzing the following test data where in all cases the addition of MoS_2 extended the effective lubrication of the base lubricant.

Four tests show how MoS_2 reduces wear

1. SHELL 4-BALL EXTREME PRESSURE TEST

(see illustration top right)—MoS_2 addition reduces wear more than 50% and increases load capacity by about 70% over base grease.

2. FALEX 2-HOUR WEAR TEST

The chart below shows how MoS_2 sustains lubrication, as proved by a reduction of 500 per cent in average wear.

Grease	Loss in Weight of Specimen
Lithium-base	1,000 mg.
Lithium-base plus 2%MoS_2*	1·98 mg-average of 3 runs

3. TIMKEN ENDURANCE TEST

(see illustration bottom right)—MoS_2* sustains lubrication well beyond the capabilities of the base grease alone, and at a lower temperature than conventional E.P. grease.

4. SIMULATED SHACKLE BOLT SERVICE TEST

Oscillating friction machine—3%MoS_2* addition virtually doubles the effective lubrication of a lithium base chassis grease—is far more effective than conventional additions.

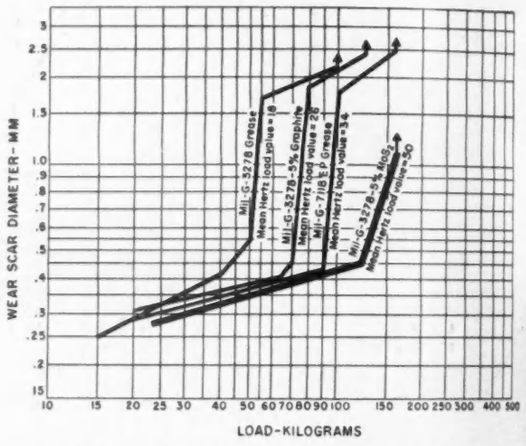
Hours to failure—average of 2 tests

Additive	None	3%MoS_2*	5%ZnO	15%ZnO
Dry	350	564	336	555
Wet	162	264	109	85

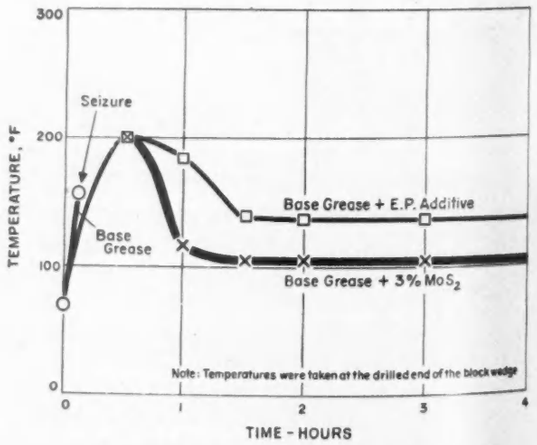
* Fine particle size.

Molybdenum Disulphide greases are manufactured in the U.K. by a number of specialist producers, whose names can be obtained, together with a copy of "MOLY-Sulfide as a Grease Additive", from :—

CLIMAX MOLYBDENUM COMPANY OF EUROPE LIMITED
99 PINSTONE STREET, SHEFFIELD 1


WEAR SCAR DIAMETER - MM
LOAD - KILOGRAMS
Mil-G-3278 Grease
Mean Hertz load value = 18
Mil-G-3278 - 5% Graphite
Mean Hertz load value = 26
Mil-G-7118 E.P. Grease
Mean Hertz load value = 34
Mil-G-3278 - 3% MoS2
Mean Hertz load value = 50

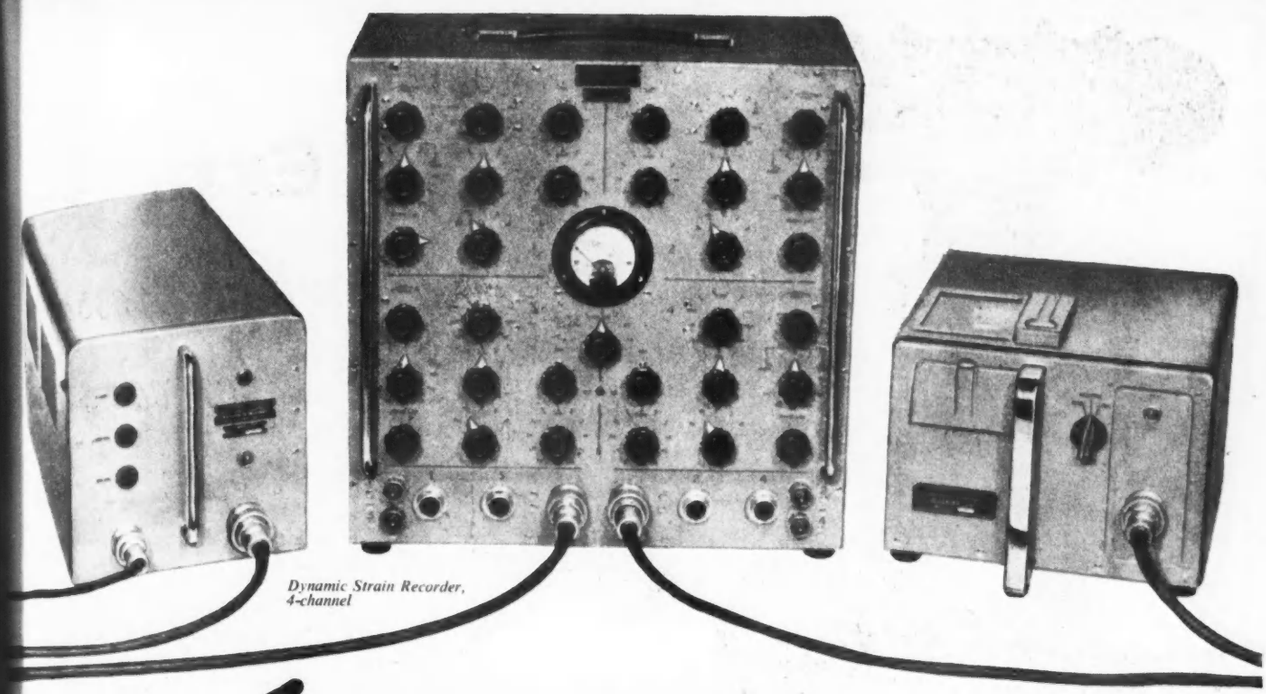
4-ball E.P. test shows the superior extreme pressure properties of MoS_2 grease over the same grease without additives. In the same test, grease containing 5% graphite had a mean Hertz load value of 26: the conventional E.P. grease Hertz value was 34.


TEMPERATURE, °F
TIME - HOURS
Seizure
Base Grease
Base Grease + E.P. Additive
Base Grease + 3% MoS2
Note: Temperatures were taken at the drilled end of the block wedge

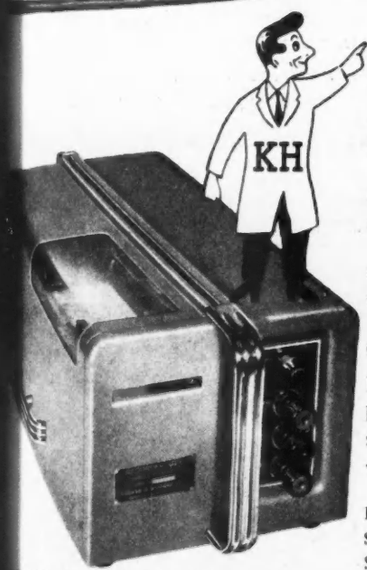
Timken endurance test clearly shows how MoS_2 functions when added to a base grease. With base grease alone, the specimen seized in about 10 minutes. With MoS_2 added, lubrication was effectively sustained throughout the test at a reduced temperature of about 100°, compared with a temperature of about 130° for the conventional E.P. grease.

MOLY-SULFIDE†

† *MOLY-Sulfide is a Climax brand name*



Dynamic Strain Recorder, 4-channel



Speed Pen Recorder Mark 5, single channel

Speed Pen Recorder Mark 2, 4-channel

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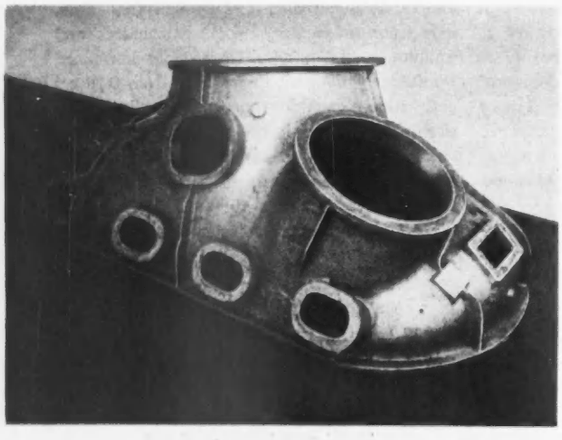

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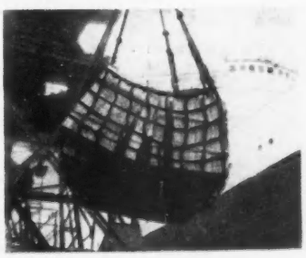

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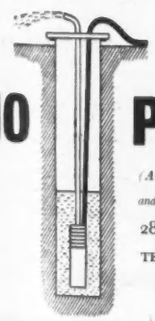
Last year over one million dollars' worth of Sumo pumps were sold in the highly competitive U.S. market. Here a consignment is being loaded into the Queen Mary at Southampton Docks.



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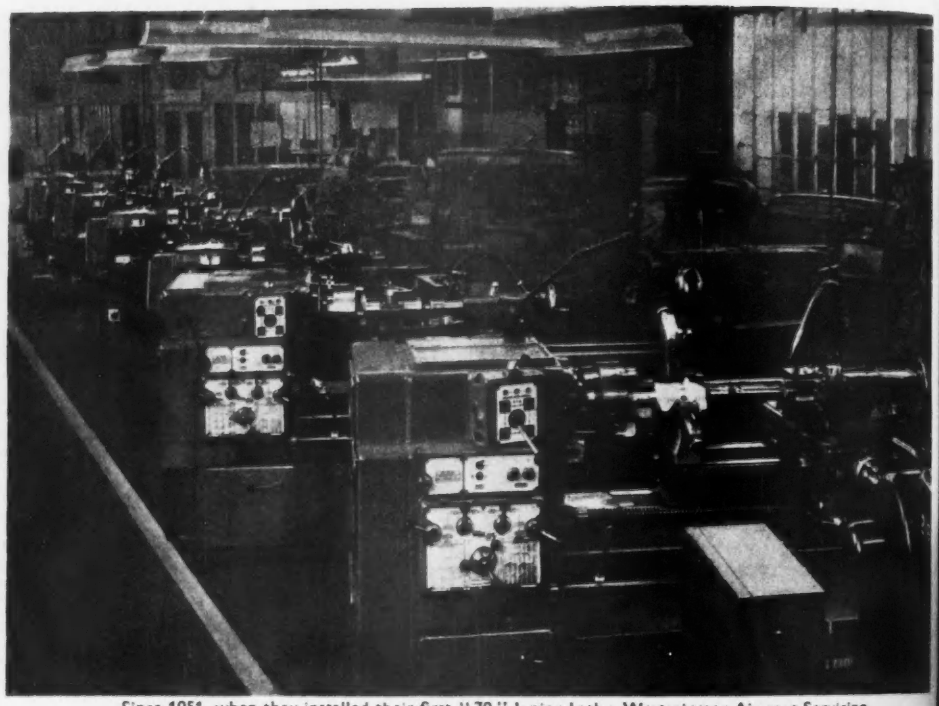

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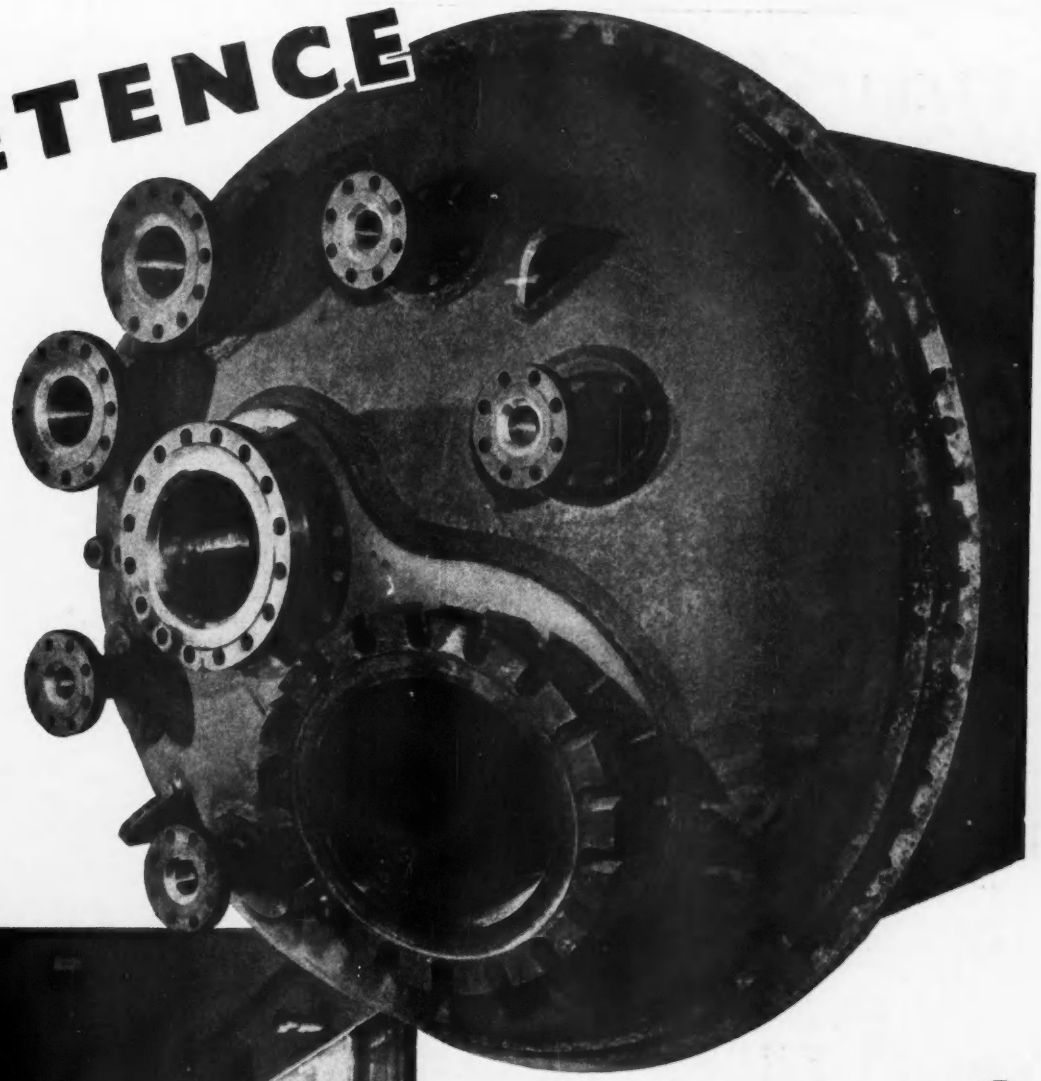

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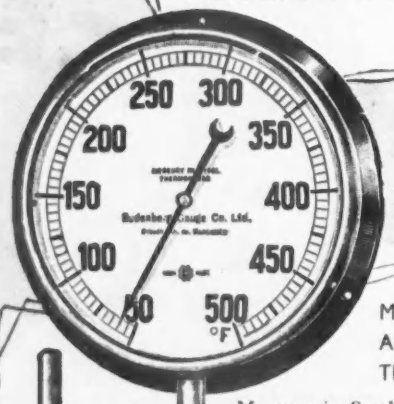

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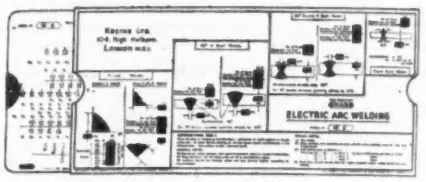

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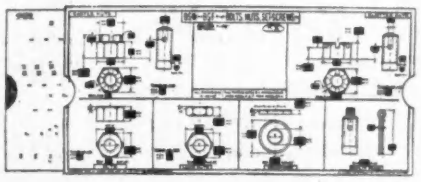

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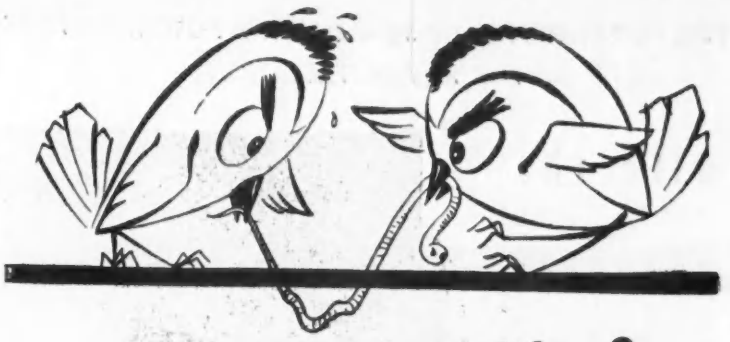

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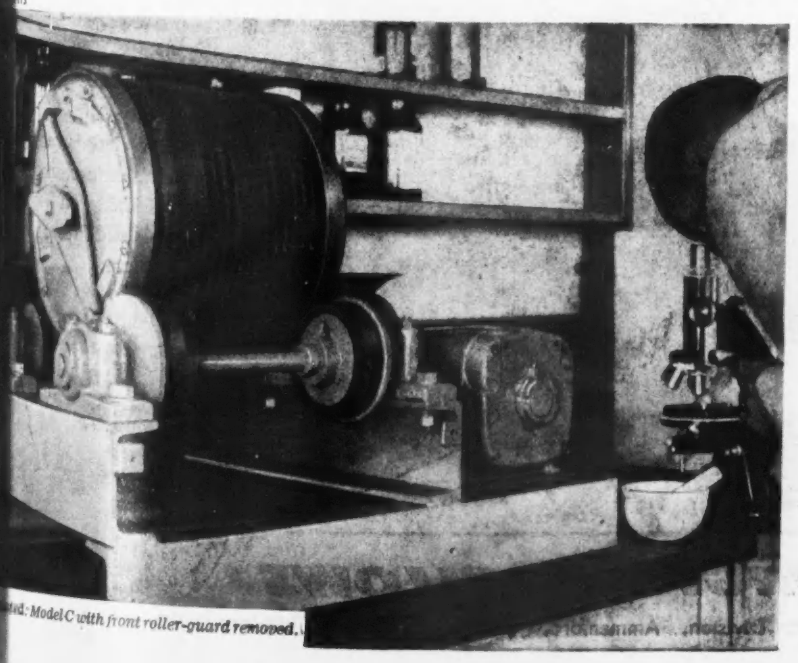

...d: Model C with front roller-guard removed.

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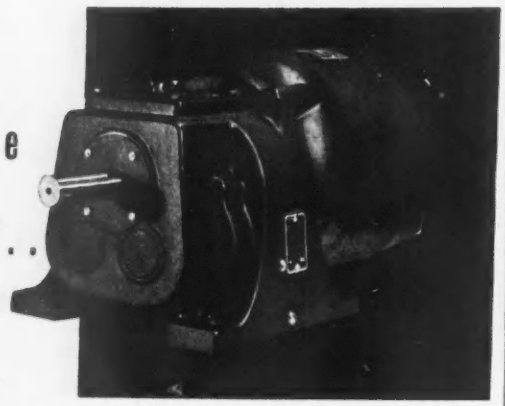

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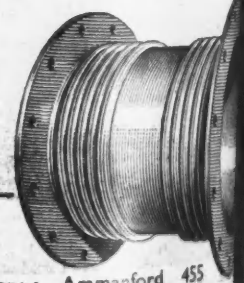

PIPES ON THE MOVE PREFER **TEDDINGTON BELLOWS**

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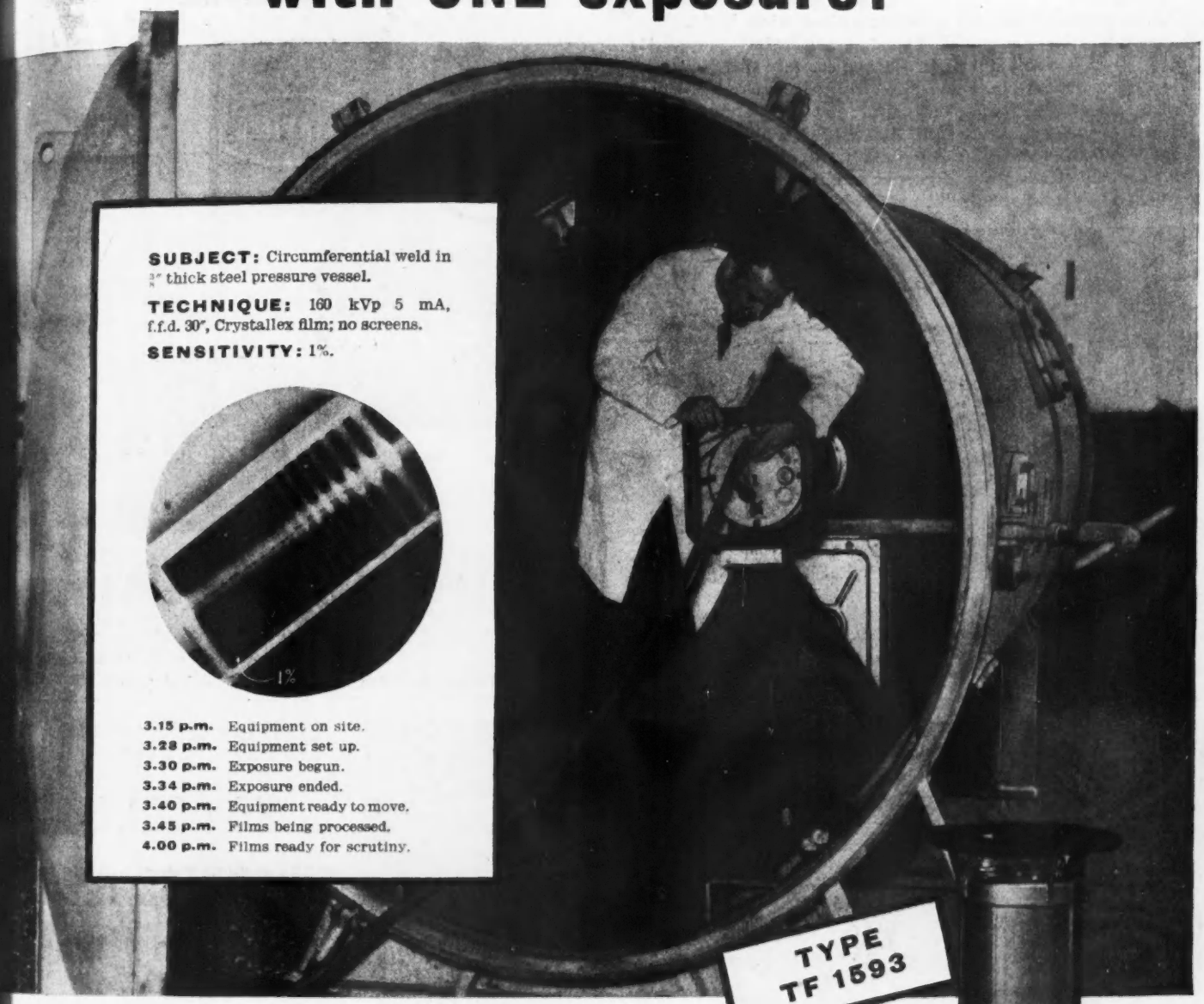
16ft. OF WELD X-RAYED IN 4 MINUTES with ONE exposure!



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TECHNIQUE: 160 kVp 5 mA, f.f.d. 30", Crystallex film; no screens.

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3.15 p.m. Equipment on site.
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IX16

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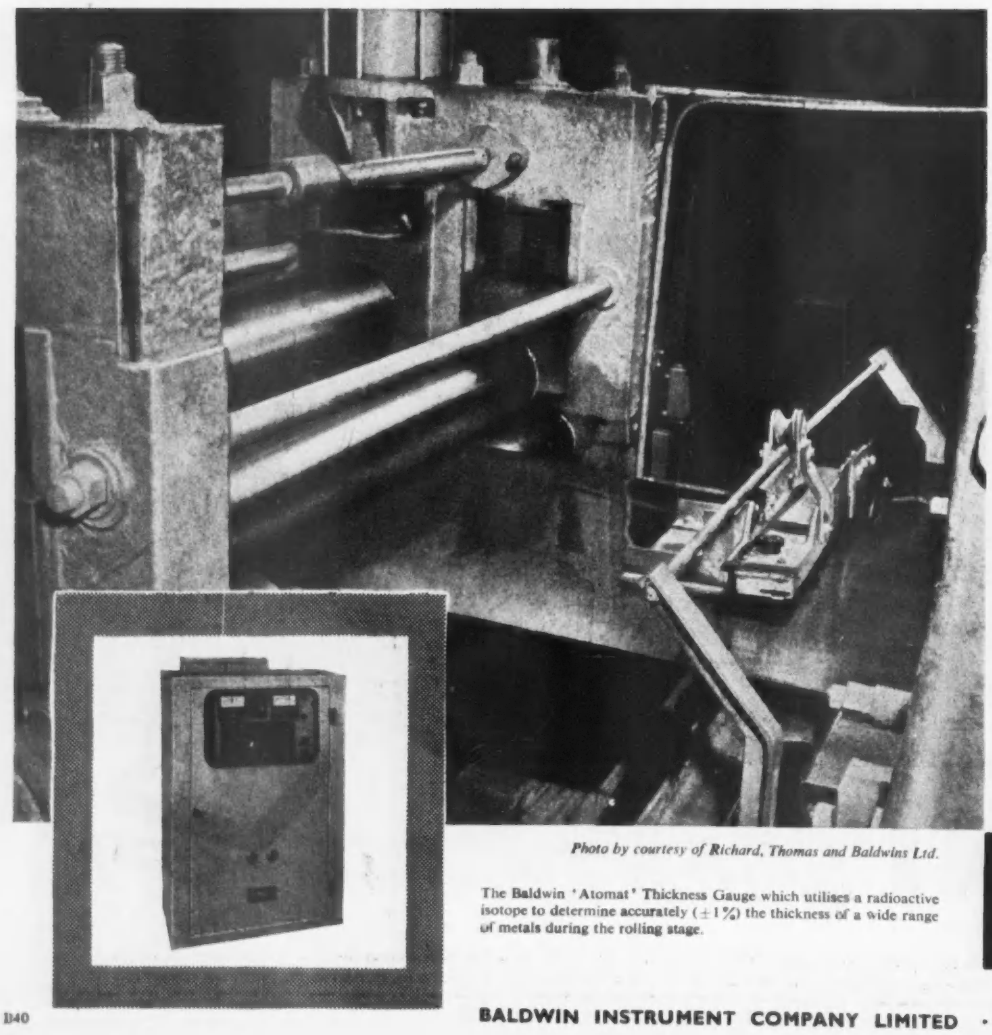

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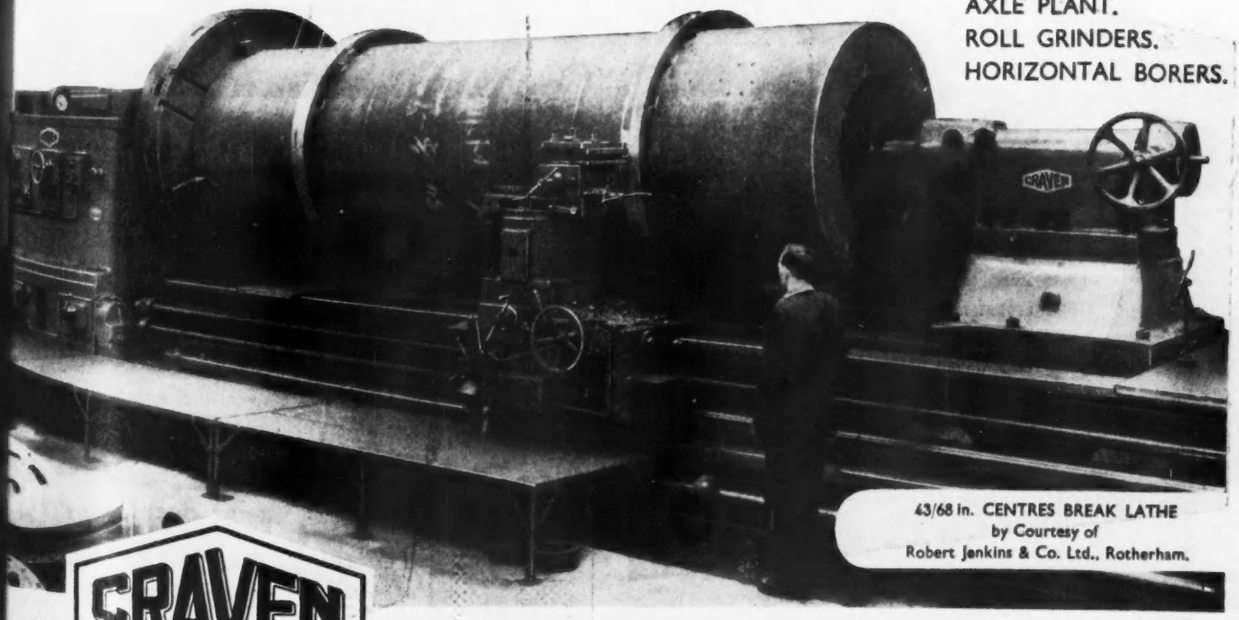

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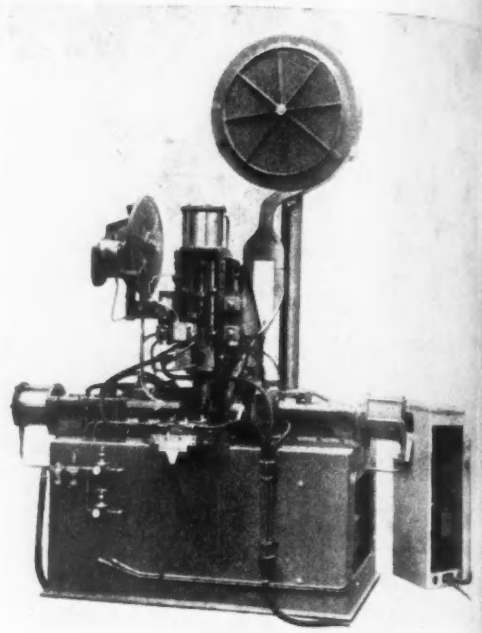

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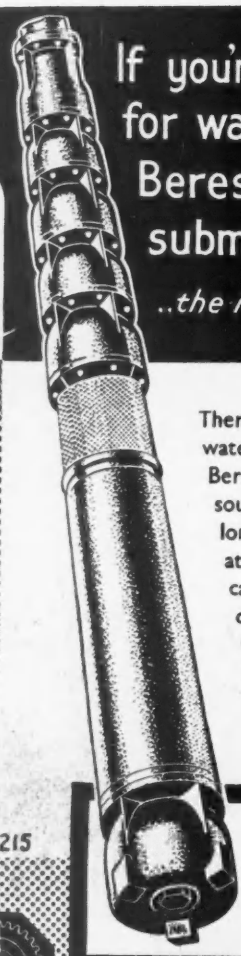

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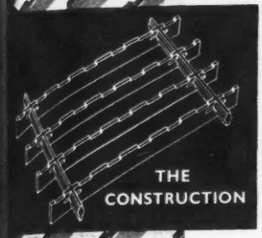

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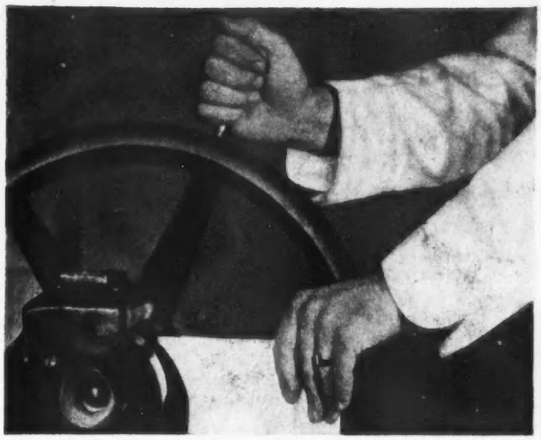

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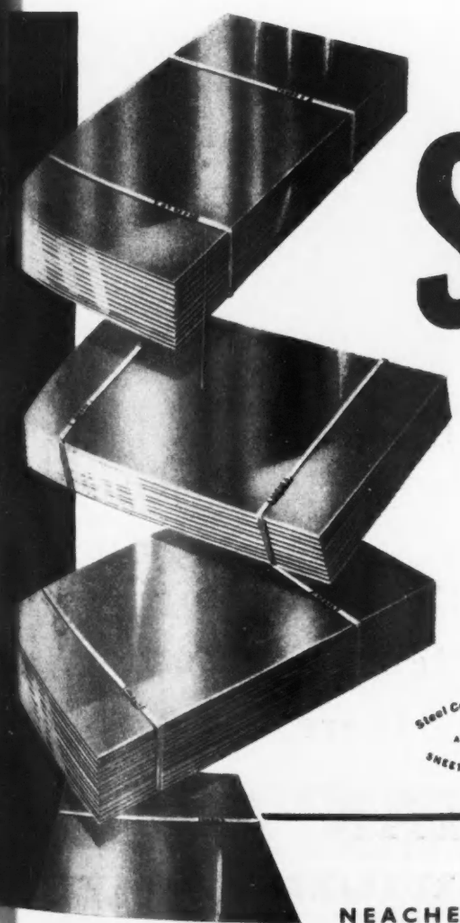

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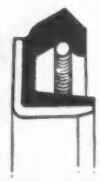
TYPE 11 P

The standard rotary shaft seal. Gives perfect sealing at high speeds and for long periods, with minimum frictional loss.

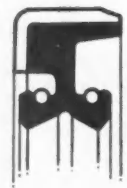
TYPE 11 P/B

As type 11 P but with the casing covered with rubber. Interchangeable with metal case seals.



TYPE 23 P

An external seal used when fitting conditions prevent the use of 11 P or 11 P/B seals.



TYPE 12 P

A rotary shaft seal used to separate two different fluids.

TYPE 13 P

Similar to type 12P but without a spring in the second lip which serves as a dust ex

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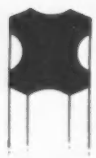
O-RINGS AND HYDRAULIC PACKINGS

TYPE 31 P

A springless seal used as a wiper or dust excluder for rotating or reciprocating shafts.

TYPE 7 P

A hydraulic and pneumatic seal chiefly on reciprocating pistons or a valve stem packing. Normally fitted in a groo



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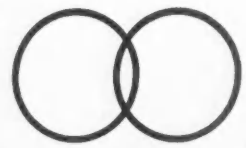

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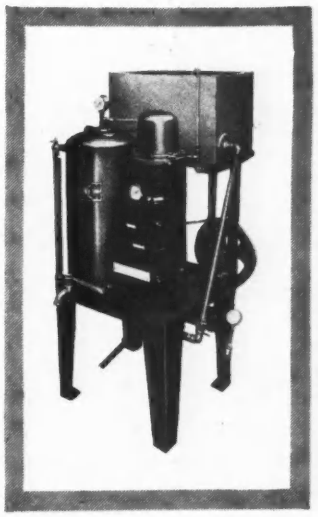

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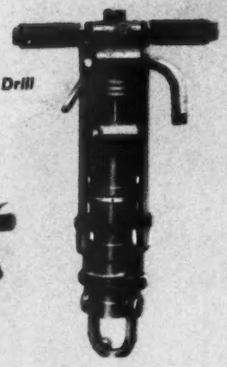
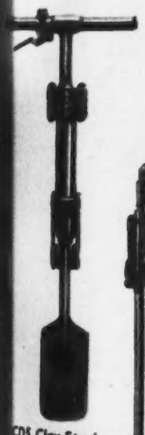
The Rotary Compressor range includes models having outputs from 120-630 cu. ft. F.A.D.



CB268 Rock Drill

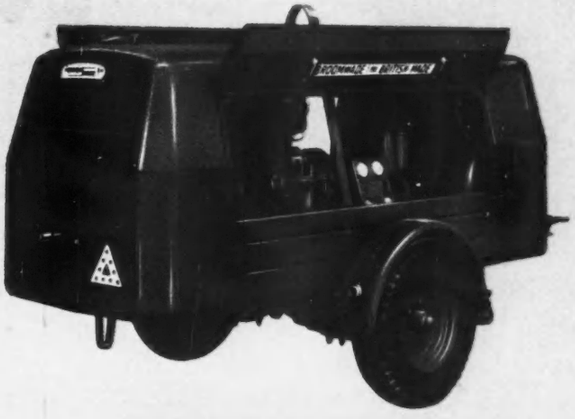
RR70 Road Breaker



CD5 Clay Spade

SR18 Rammer

Type WR120 two-stage rotary air compressor, delivering 120 cu. ft. free air per minute at 100 lb. per sq. in. pressure. Powered by Perkins diesel engine. This set is also available with a Ford petrol engine or Petter McLaren air-cooled diesel engine.



Type WR250 two-stage rotary air compressor, delivering 250 cu. ft. of free air per minute at 100 lb. per sq. in. pressure. Powered by a Leyland diesel engine.

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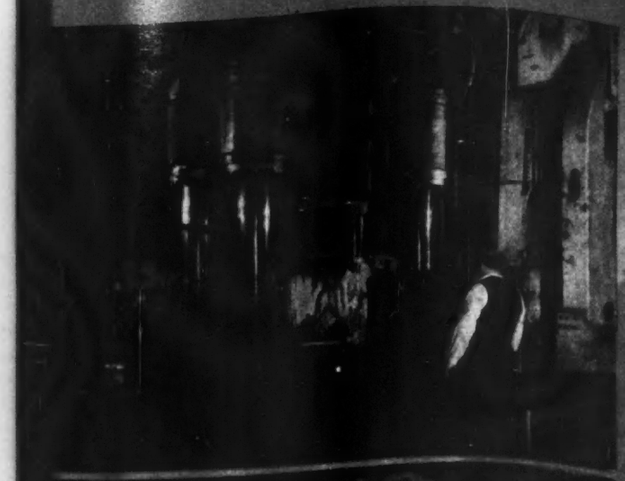
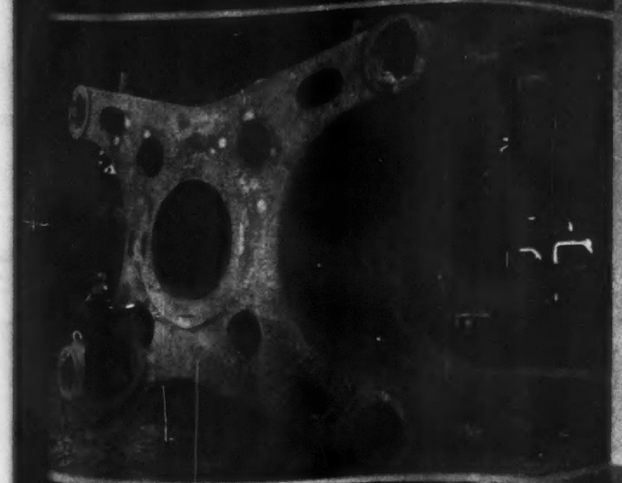
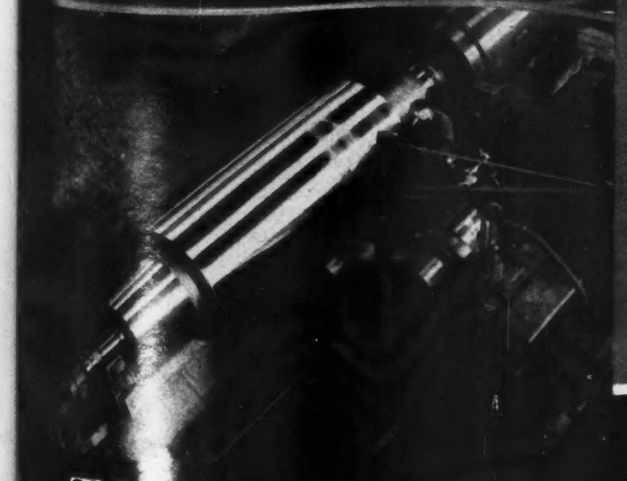


A Company's reputation is built up on the quality of the work which it produces. During the past 100 years the name of The Darlington Forge Limited has grown to be associated throughout the world with the production of Forgings and Castings of the highest order for the Marine and General Engineering Industries.



In the past, the Company's moulding pits and forging presses have produced structural and engine components for many of the world's greatest ships. Today they are making their own invaluable contribution to the expansion of Britain's heavy industrial capacity.



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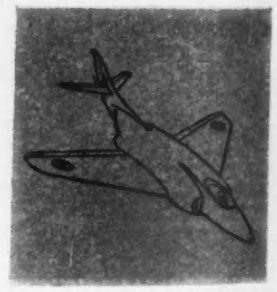
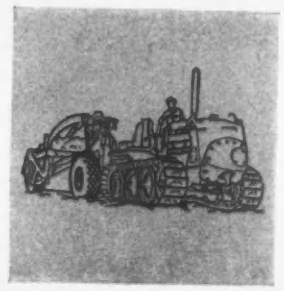
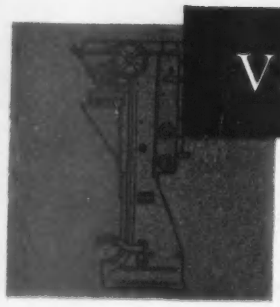
In developing power station auxiliary plant to match the advances in high efficiency turbo-alternators and boilers, Vickers-Armstrongs can draw on an outstanding background of engineering achievement. History-making aircraft like the Viscount and Valiant... fast ocean liners such as the 29,000-ton 'Orsova'... these are headline news. Yet, in their own fields, hundreds of other products of Vickers-Armstrongs are equally important. Whether complex or simple, each shares the same background of outstanding design and sound construction: each solves critical engineering problems.



Power station plant designed and constructed by Vickers-Armstrongs is noted for its efficiency and dependability. The range of equipment includes condensers, feed heaters, de-aereators, evaporating plant and circulating water pumps. In the last few years, the contracts received by the company for this type of plant from the Central Electricity Authority and from overseas organisations involve power stations whose total output is nearly 3,000,000 kW.





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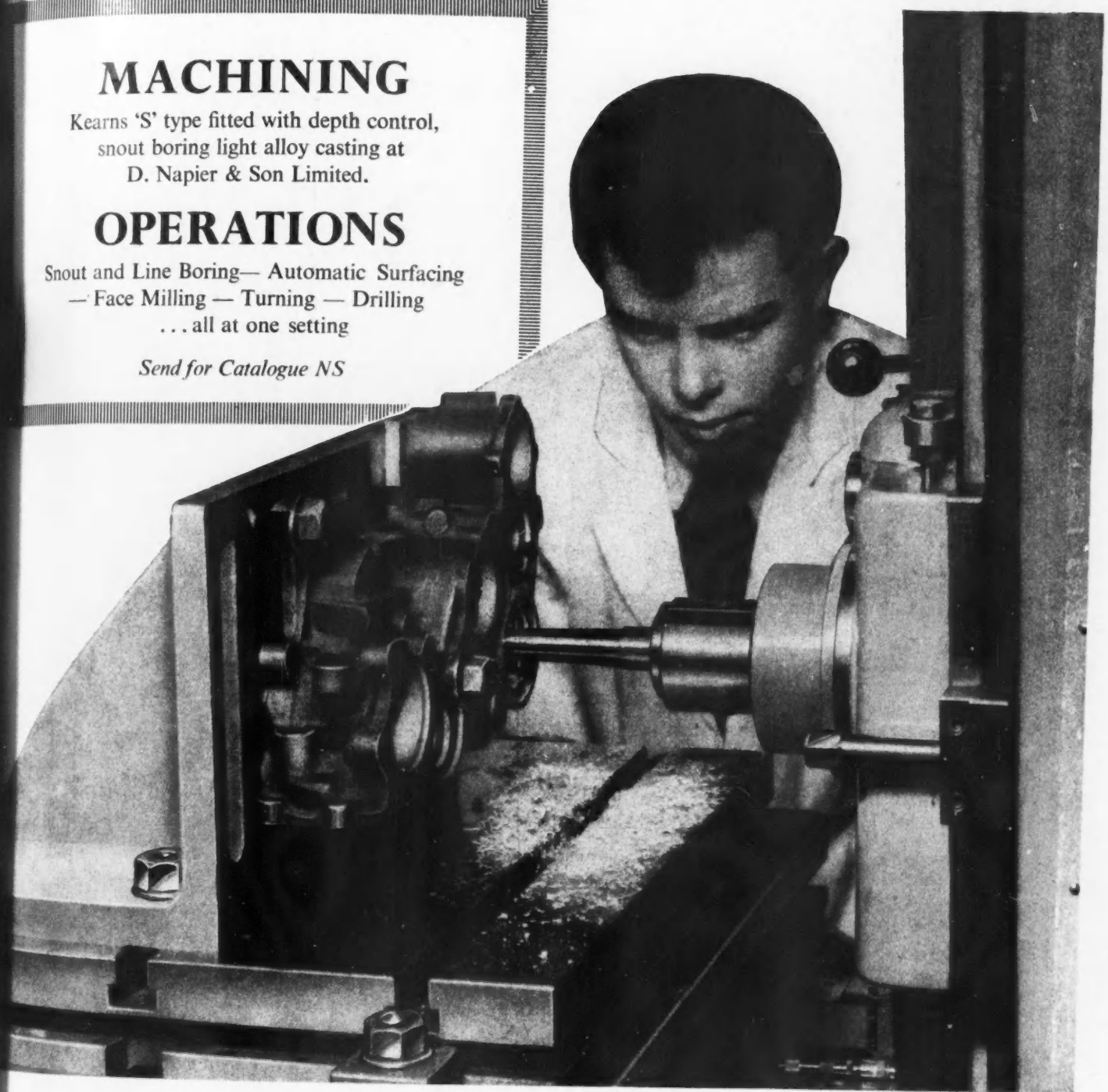

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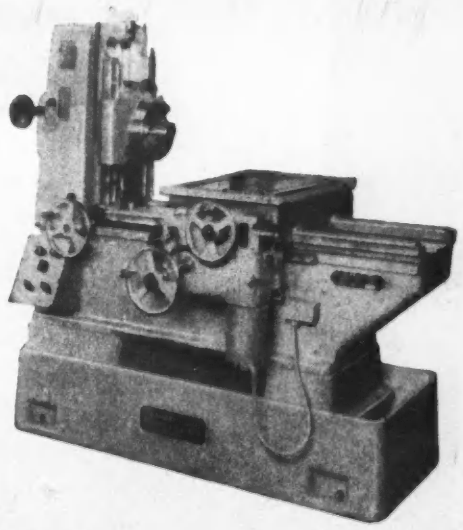

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METROVICK Electrodes

This illustration of the low pressure casing for one of the 100 MW Metropolitan-Vickers steam turbines at Castle Donington—the largest thermal power station in Europe—is yet another example of the skill of the fabricator.
The physical size of these turbines is relatively small for the output, but as fabrications they still come within the realm of giants.
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The casing comprises two fabrications, the top cover weighs 9 tons and the bottom section 29 tons. Both sections were constructed in mild steel from 1 and 1½ inches thick plate, bars up to 3 inches thick, and a 12 inch thick forging which forms part of the bearing housing.
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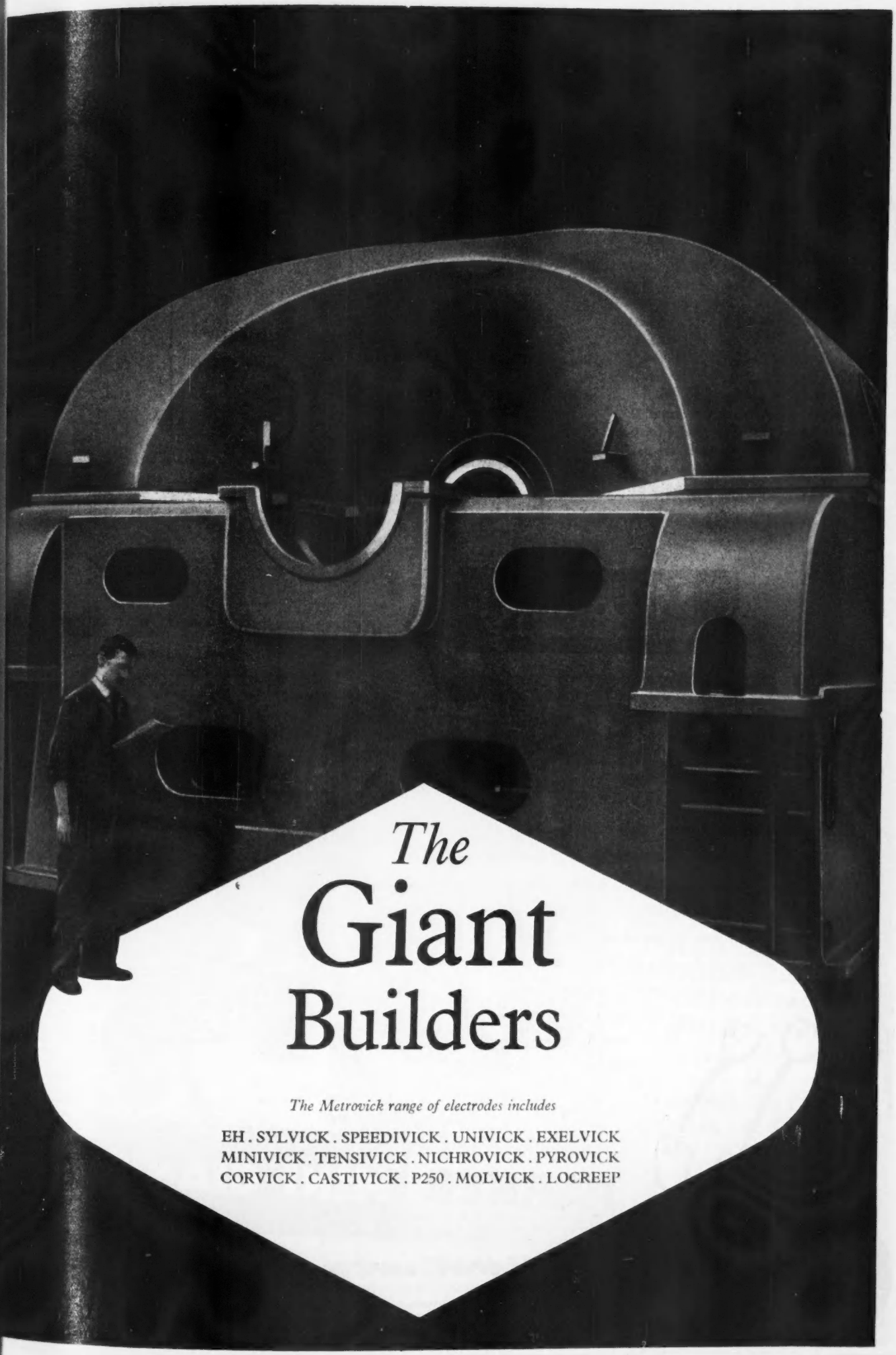

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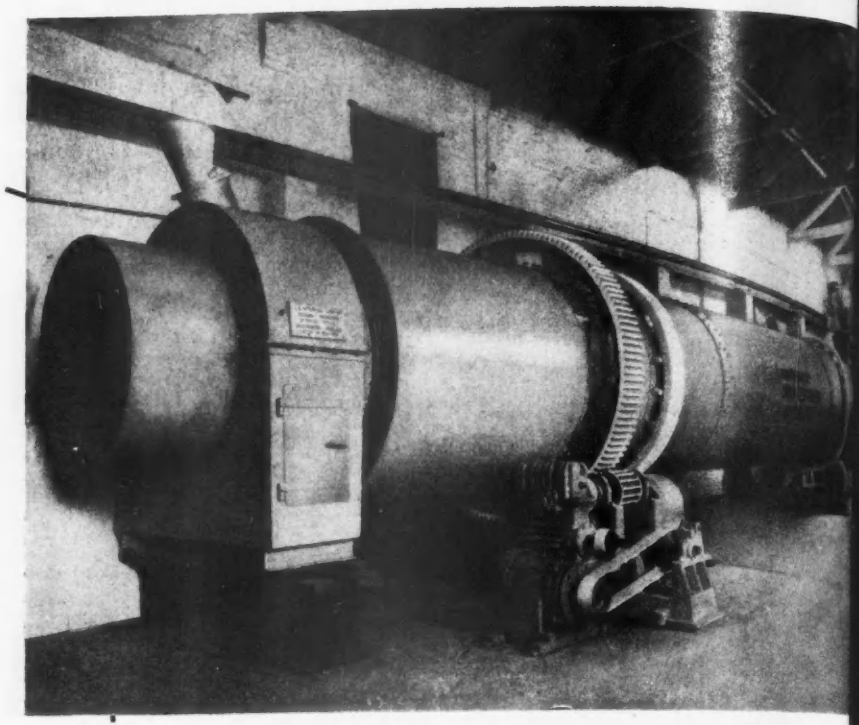

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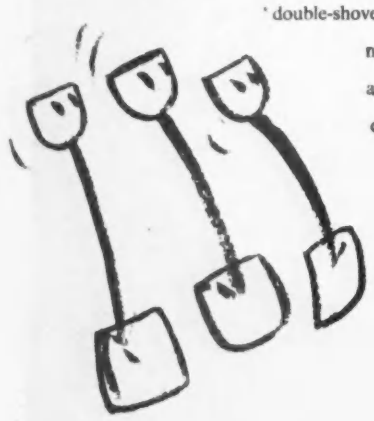

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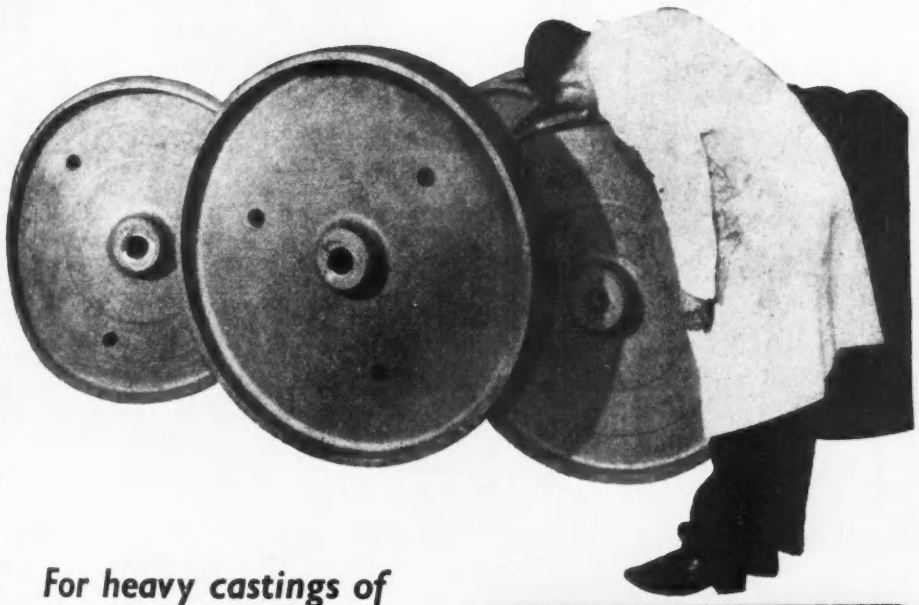

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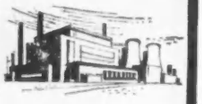
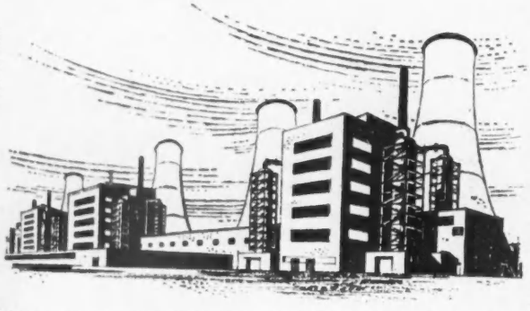


Newalls have carried out the thermal insulation contracts on many of the British Power Stations built since the war.



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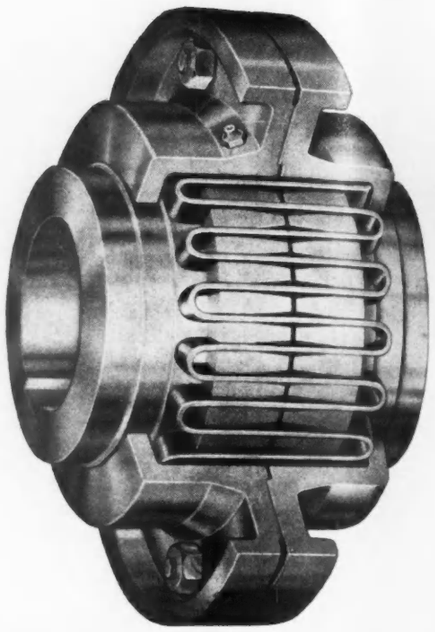

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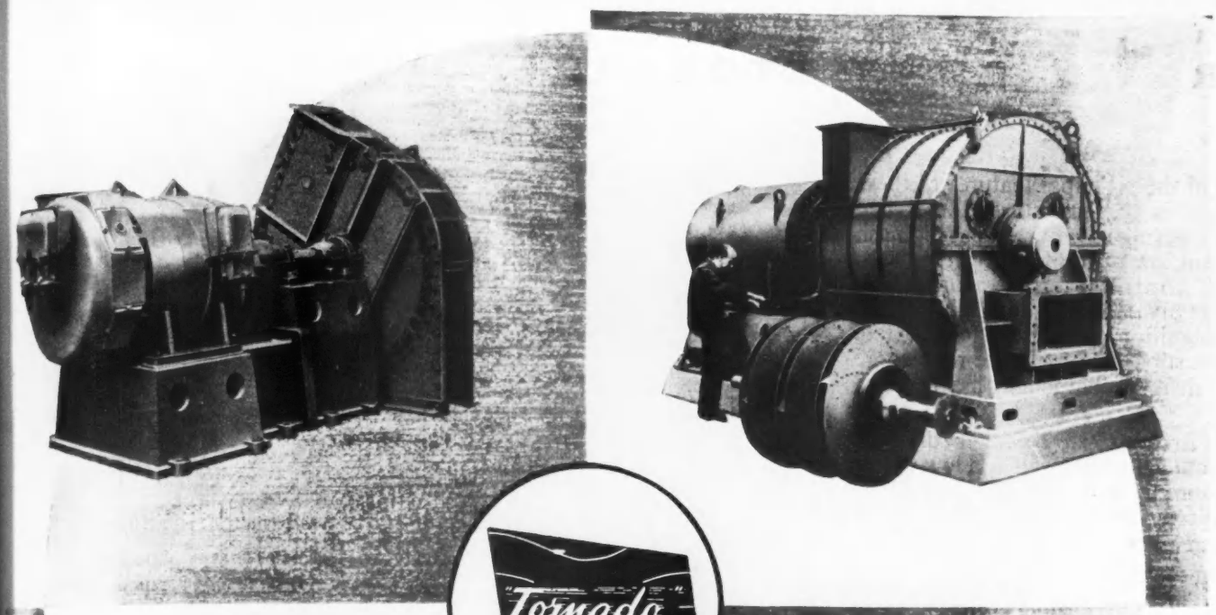

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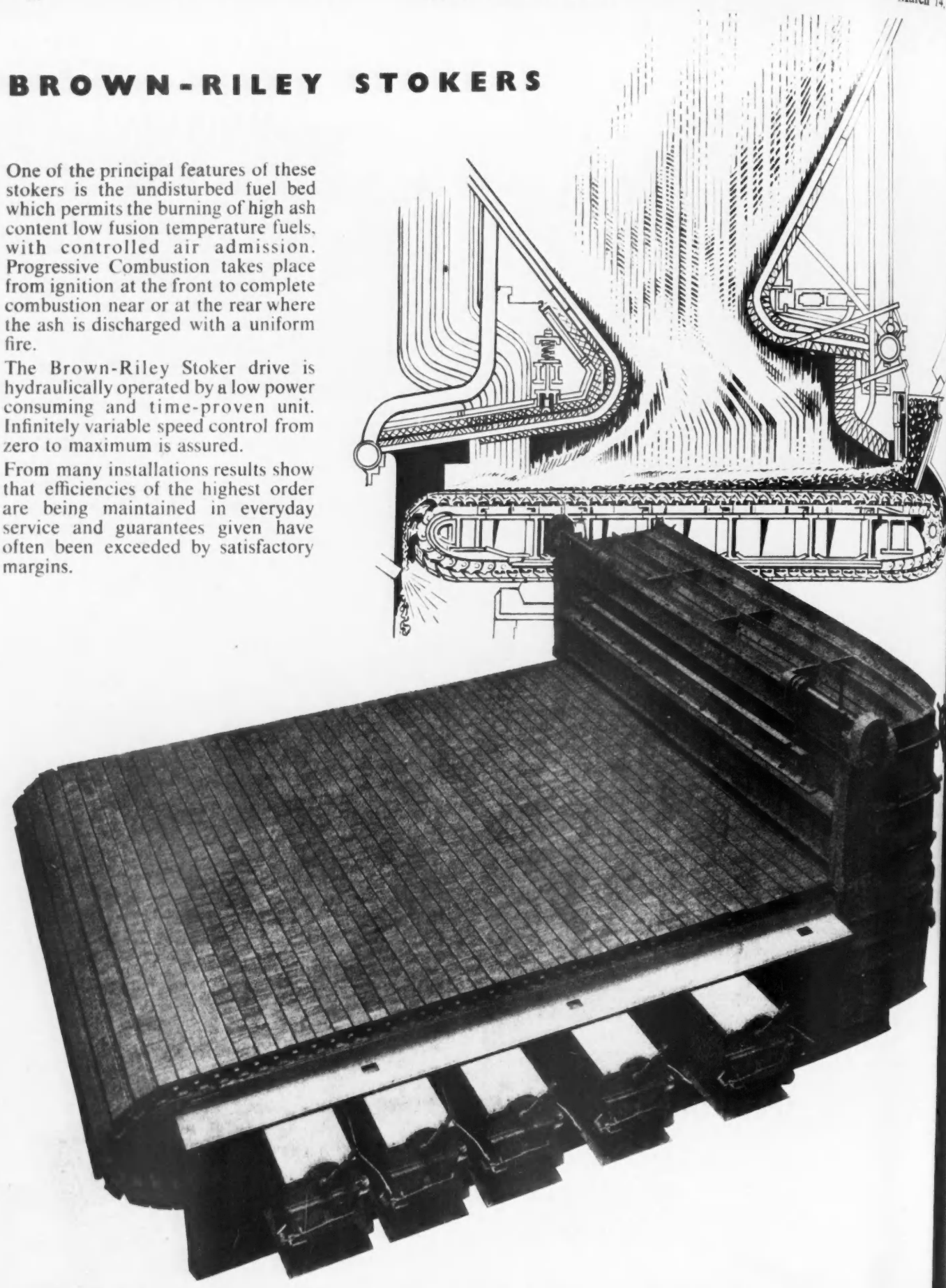

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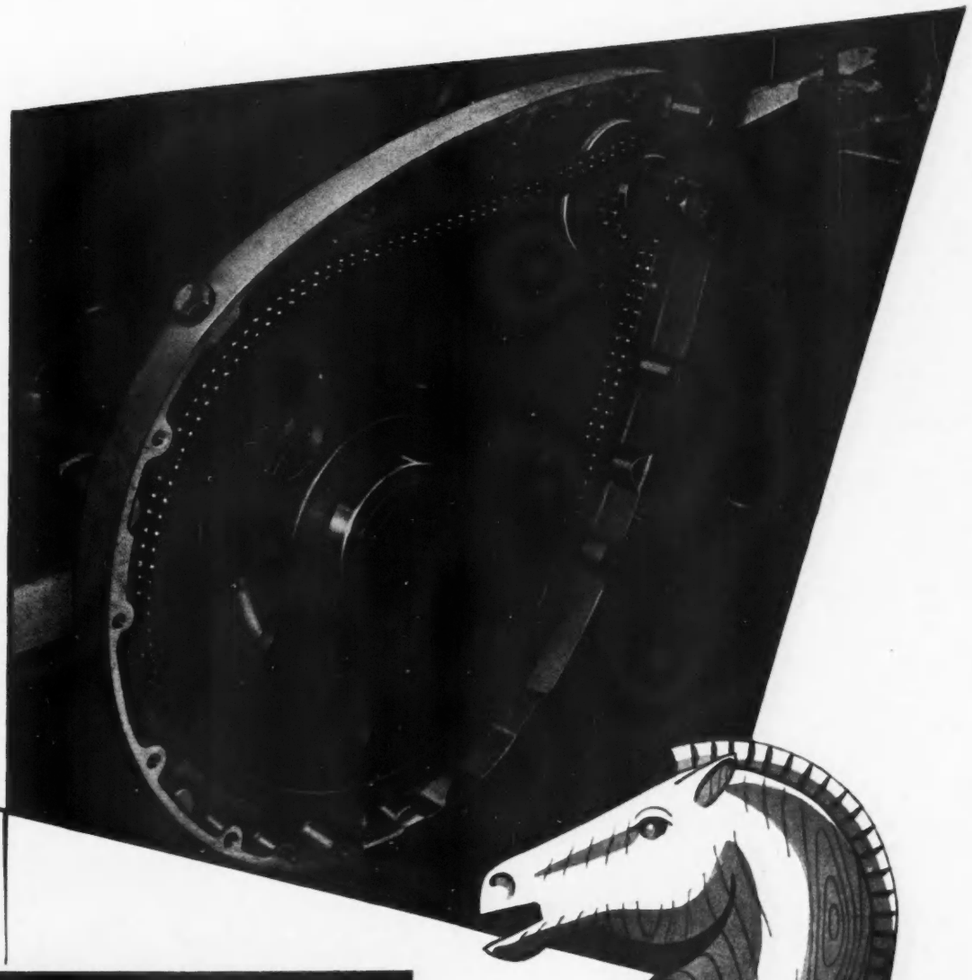

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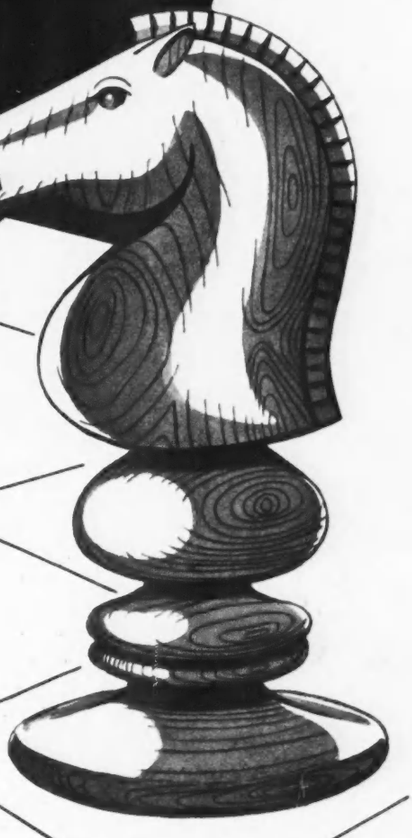

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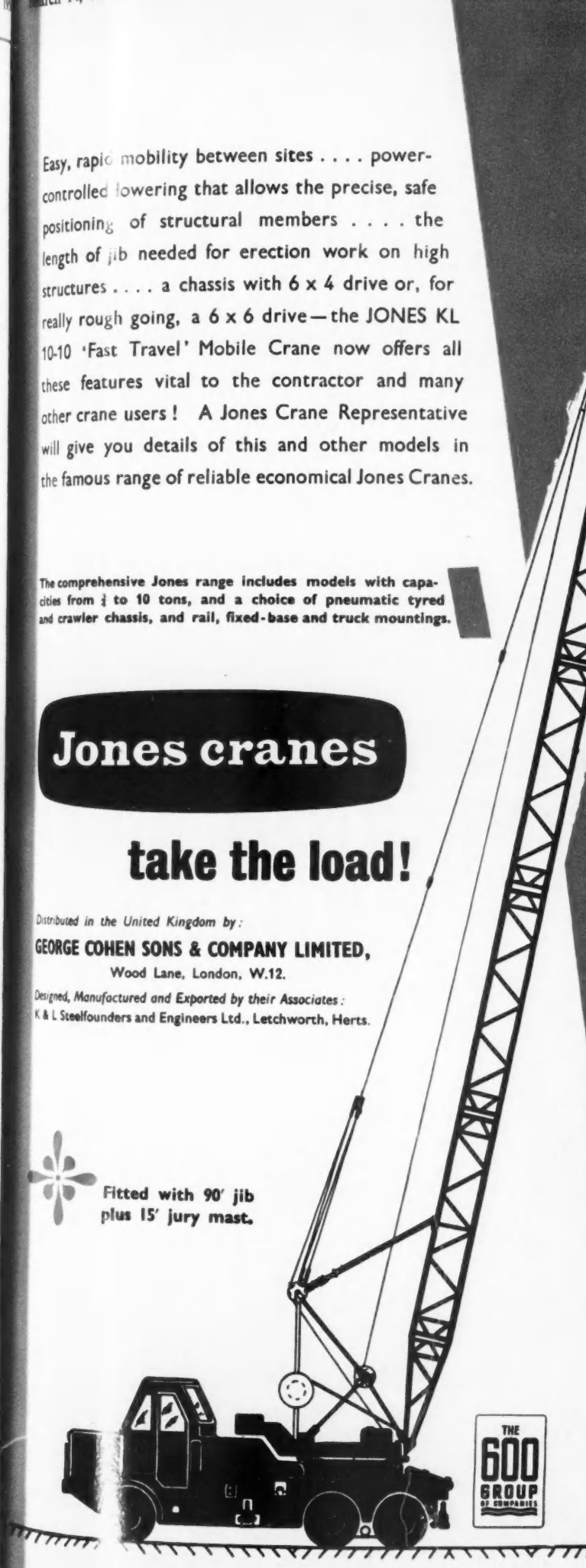

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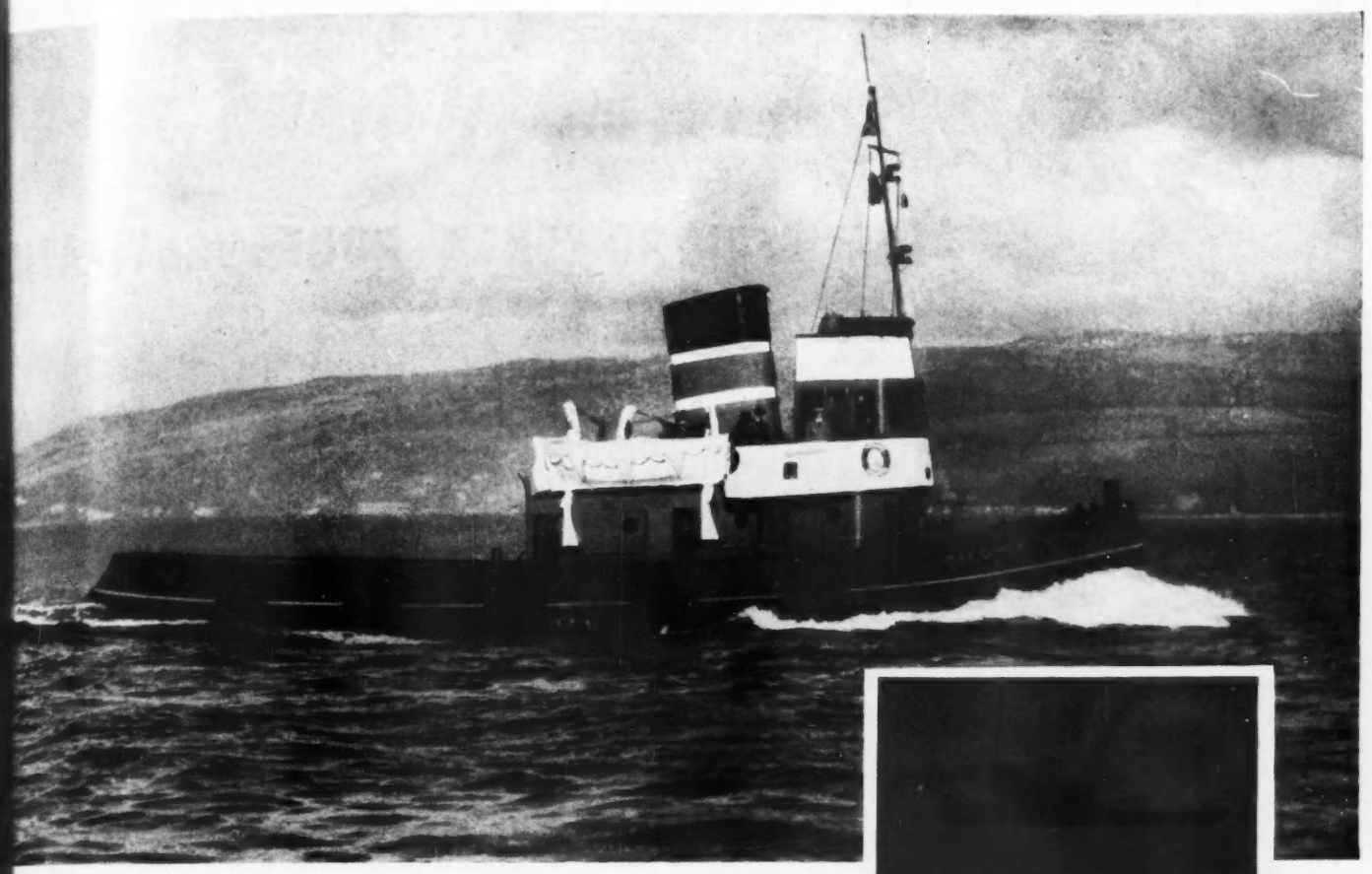

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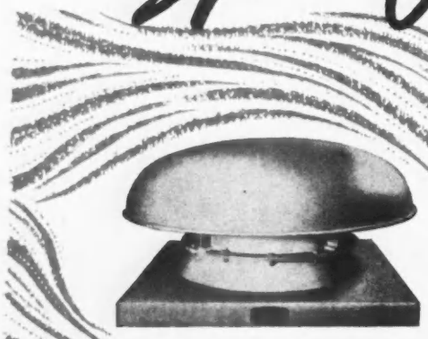

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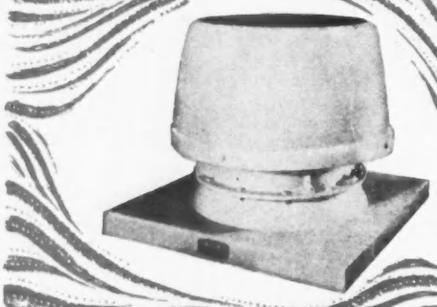

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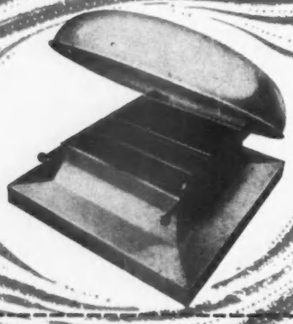

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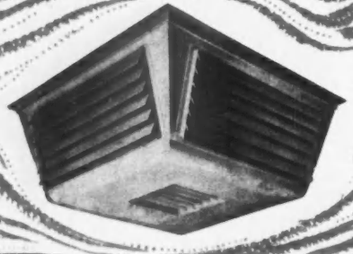

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It is a new high performance additive developed and blended specifically to promote constant high level combustion efficiency of all grades of fuel oil, ensuring maximum heat release from every gallon of fuel burned. Blended into FLAME-RITE are functional elements exclusive to FLAME-RITE developed by intensive laboratory research and confirmed by two years rigorous field testing. Basic materials have been selected for chemical stability, mutual compatibility and strong affinity for all fuel oils, ensuring a highly miscible product of constant performance which blends freely and becomes completely integrated with bulk stocks.

WHAT FLAME-RITE DOES

● **BOOSTS HEAT OUTPUT . . .** Whatever type of oil-burning equipment is used the addition of FLAME-RITE to the fuel improves flame efficiency. A surface tension agent ensures complete and even atomization of all fuel passing through the burner, exposing the maximum surface area of fuel to the air supply, and so ensuring the hottest possible flame from any given amount of fuel.

● **PREVENTS CARBON BUILD-UP . . .** Carbon build-up on sprayer nozzles and burner cups prevents uniform mixing of air and fuel, causes irregular flame patterns and inefficient combustion as shown by sparking, streaky, or lopsided flames.
FLAME-RITE combats nozzle and cup fouling by carbon and reduces nozzle changing and cleaning operations to occasional routine examinations.

● **PREVENTS SLUDGE FORMATION . . .** FLAME-RITE has powerful anti-oxidant and dispersant characteristics; sludge formation is prevented by the anti-oxidant: coagulation and precipitation of suspended matter is prevented by the dispersant. Storage tanks are kept free of sludge, intervals between filter screen cleanings are lengthened, and all fuel bought is maintained in combustible form.

● **COMBATS CORROSION . . .** Capital equipment requires protection from corrosion which attacks the unseen internal surfaces of fuel tanks and pipe lines as well as the visible outer surfaces. The FLAME-RITE formula includes a powerful corrosion inhibitor which protects the inaccessible interiors of storage tanks and pipe lines against deterioration by corrosion.

m1/1

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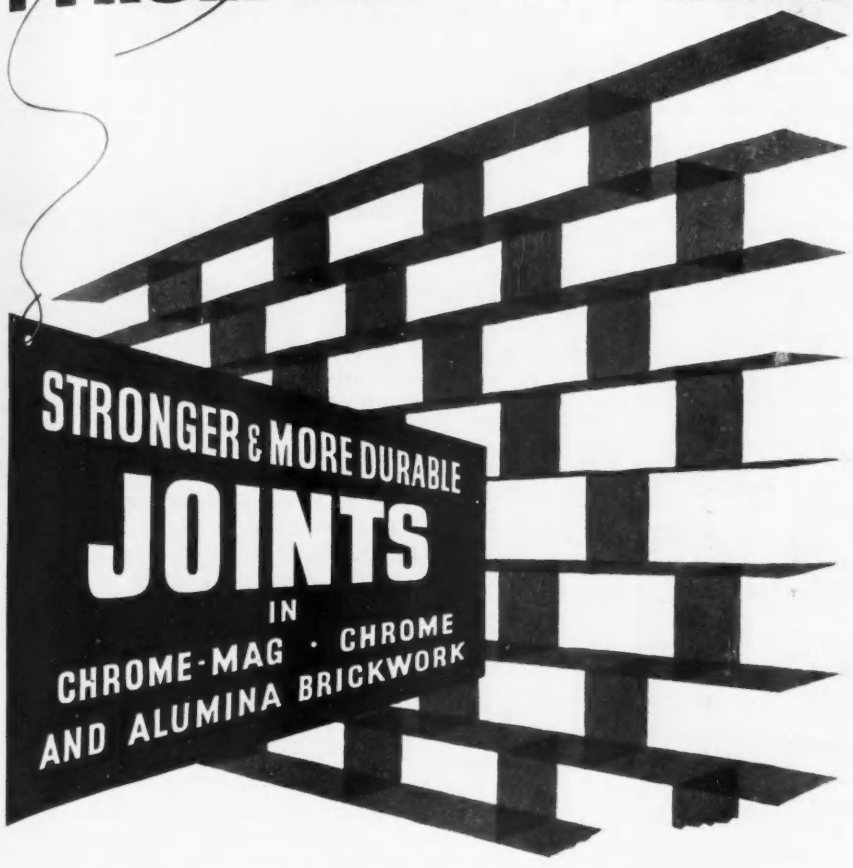
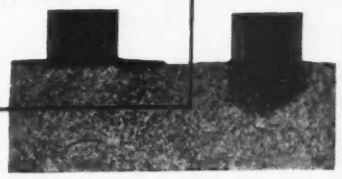


Pyrolyte High Temperature Cement is made from high grade chrome ore with small additions of other compounds to promote plasticity and air-setting properties. It has a very high melting point (1730°C.) and is chemically neutral. Pyrolyte is used for jointing all types of bricks including chrome-magnesite, chrome, alumina firebricks, etc.

Surface of firebrick protected from slag attack by Pyrolyte.



Pyrolyte provides an excellent protective wash for firebrick work. Illustration shows a firebrick partly treated by a Pyrolyte wash and partly untreated. The absence of slag penetration on the treated surface indicates the high slag-resisting properties of Pyrolyte High Temperature Cement. (The brick was heated to a temperature of 1500/1550°C.)

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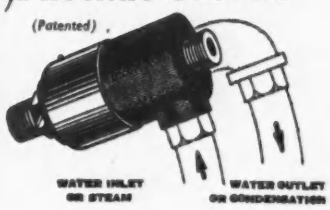

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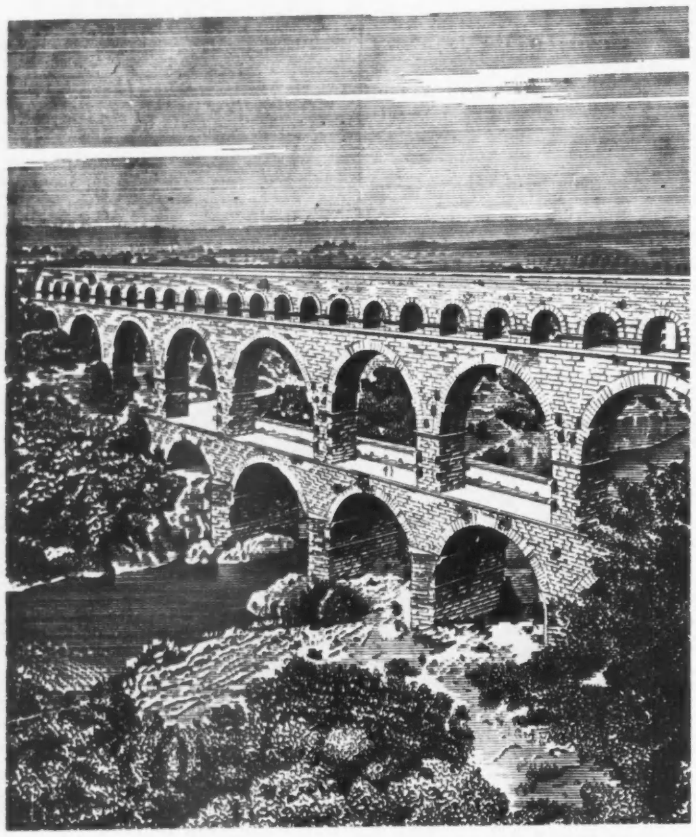

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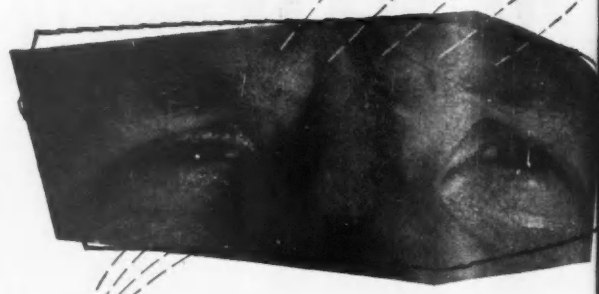

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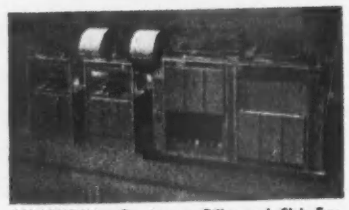

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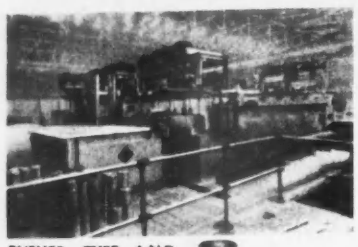

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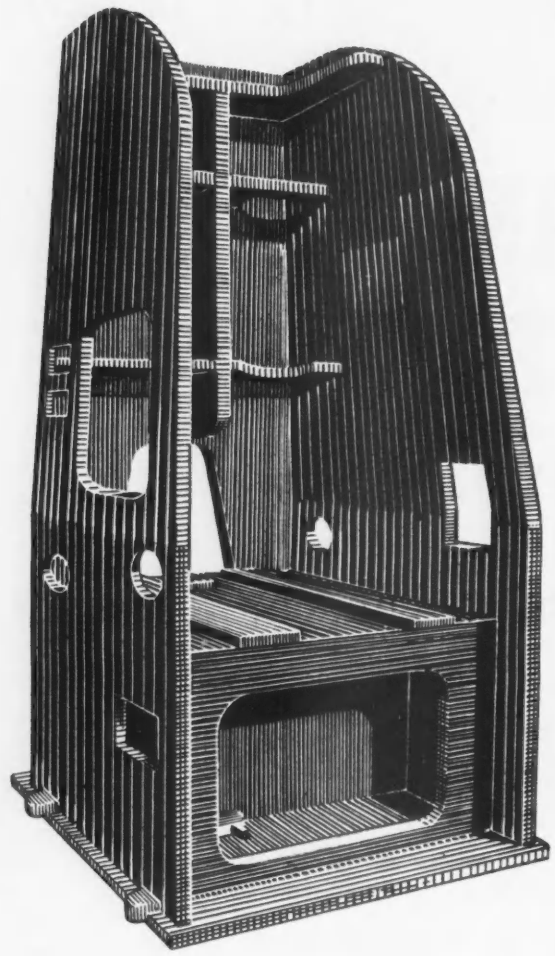

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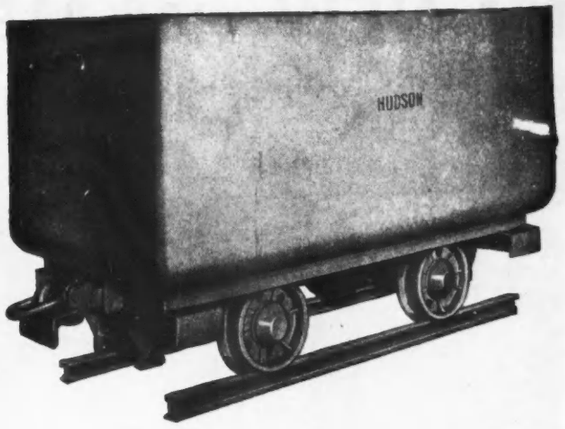

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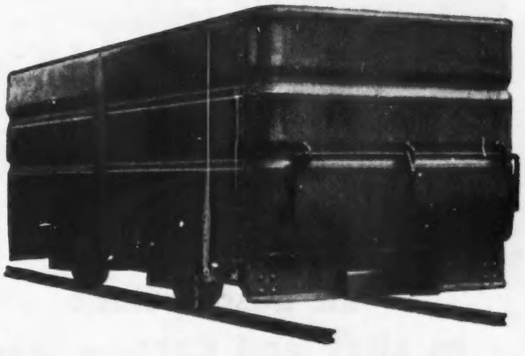

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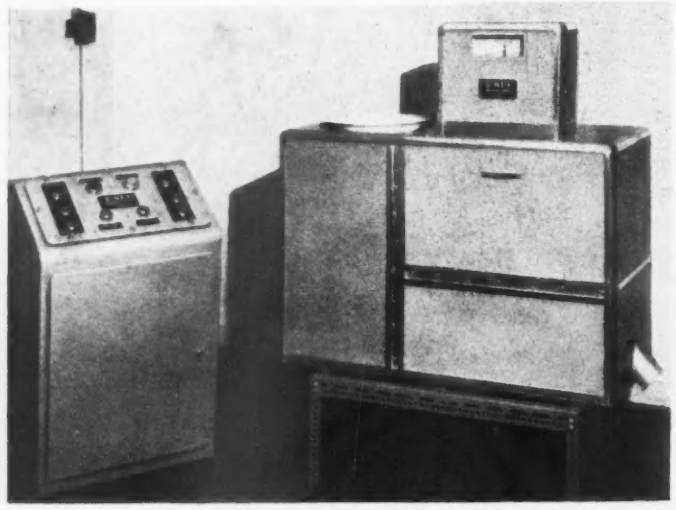

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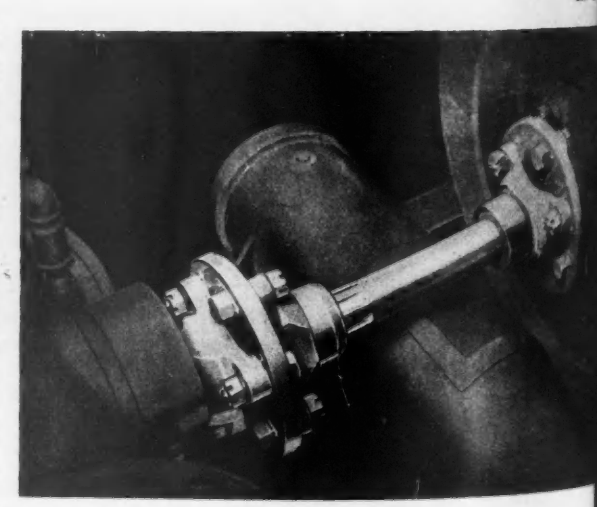

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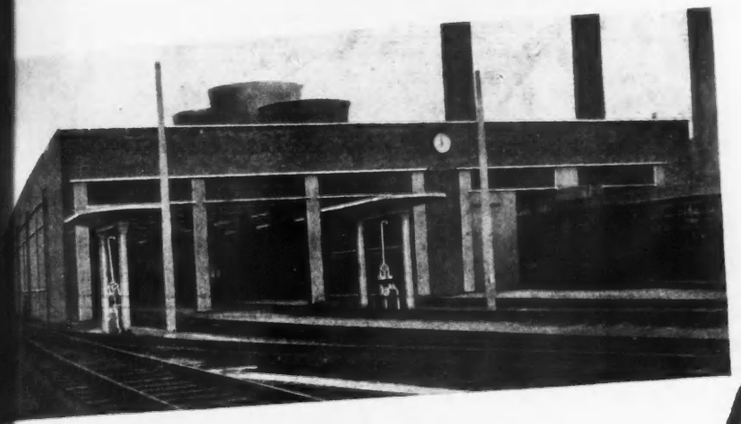

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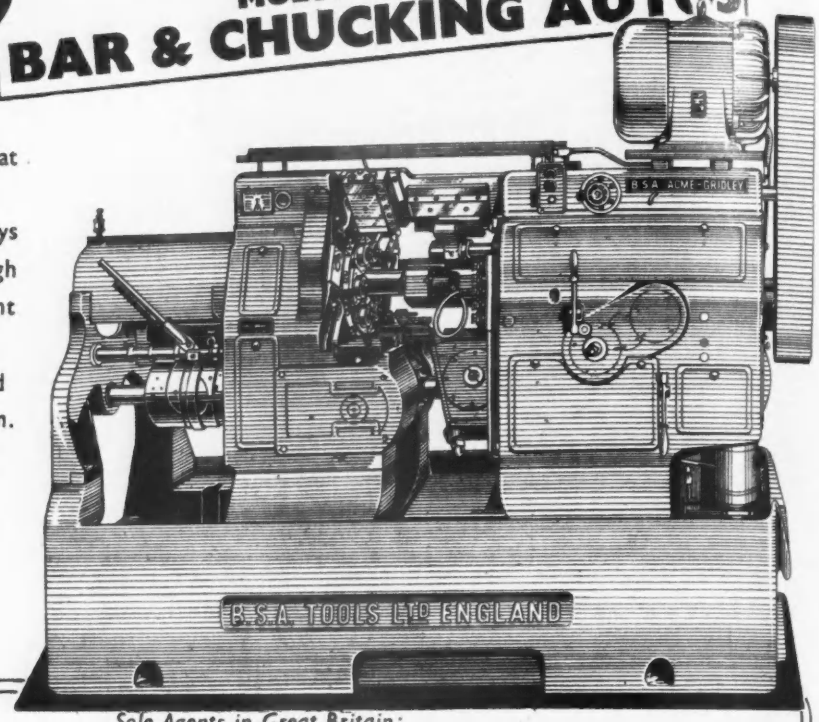

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THE ENGINEER

No. 5329 MARCH 14, 1958 VOL. 205

THE ROAD PROGRAMME

Mr. Watkinson, the Minister of Transport and Civil Aviation, spoke again on the country's road programme, on March 9, at the annual luncheon of the Asphalt Roads Association. This year, he said, we were seeing the beginnings of the largest programme of road construction that the country had ever had—£240 million worth would be authorised in the next four years. We have previously interpreted Mr. Watkinson in these columns as stating that that same sum would be spent in the next four years. Authorisation and expenditure are, of course, quite different, and unless we have been exceptionally dense, it would appear that the Ministry of Transport's pundits delight in obfuscating the distinction between these two quantities, since the illusion is then given that the road programme is larger than it actually is. This illusion is strengthened by the stream of publicity attending each event in road construction. It can be dispelled only by giving estimates of actual expenditure. Whether or not the road programme is big enough and bold enough, can then be discussed without ambiguity, since some pretty reliable yardsticks to measure it with were given at the conference on the highway needs of Great Britain, held at the Institution of Civil Engineers last November.

Whatever criticism is levelled against the road programme, however, it is indisputable that some worthwhile road construction is now being started for the first time since the war. All of this could not have been done, we are told, without years of preparatory work and planning, which in the current jargon of the building trade is called " pre-planning." One interesting technical aspect of the contracts which have just recently been let is the diversity of method in carriageway construction. This matter was referred to by Mr. Watkinson, and can best be explained by quoting from his speech. " It is a fundamental feature of the specification that we have given full attention to all acceptable alternative types of carriageway construction," he said. " We do this so that contractors may be encouraged to make the best use of materials available locally, and so that they may thus get the maximum economy. Sometimes we give alternative specifications when we invite tenders so that we can make a final choice when firm figures for costs are known. We did this for the London to Birmingham motorway and the St. Albans by-pass, where we asked for tenders for reinforced concrete, for asphalt on lean rolled concrete and for asphalt on waterbound Macadam." " From the tenders received," Mr. Watkinson continued " we selected those considered to be the most suitable and economic. It is interesting to note the diversity of result. Two of the London to Birmingham contracts will be asphalt on lean rolled concrete while the other two will be asphalt on waterbound Macadam. The St. Albans by-pass will be reinforced concrete. The contracts which have already been let for the Ross motorway are for a granular sub-base of quarry waste, followed by two layers of crushed stone, a layer of bituminous Macadam and finally of cold asphalt with pre-coated chippings. Then after traffic has been on the road for a year, we shall add a coat of hot rolled asphalt with chippings. I do not think there can be any clearer indication that we have no dogmatic views on what is best for the country as a whole. We are providing for a variety of road constructions with the most modern available techniques. As a result we shall get very valuable information on their comparative riding and wearing qualities and the experience gained will be of great use in devising even better methods for other motorways to come."

DEFENCE CO-OPERATION WITH THE U.S.A.

Owing to the inter-service rivalry in the United States, it is still difficult to judge—despite the Army's success in placing the satellite " Explorer " in orbit—which of the three intermediate range ballistic rockets now being developed—the Army " Jupiter," the Air Force " Thor," or the Navy " Polaris "—will eventually prove the more effective missile or which will be the first to be operational. Until the Russian claim to have launched an intercontinental rocket, Congress and the whole American nation were satisfied that the United States Strategic Air Force would give them adequate protection for some years to come. The development of intercontinental and intermediate range rockets was thus given no urgent priority until it became evident that the former were not likely to become available until the mid-sixties. A major effort was therefore concentrated on the intermediate range rocket, all three services developing their own brands, with the Army and Air Force missiles apparently well ahead. It is presumably these two missiles which the President agreed at Bermuda to supply to Great Britain. Since then, however, the spectacular success of the submarine " Nautilus," the practicability of launching intermediate rockets from large nuclear-powered submarines when submerged, and the realisation that the " Thor " and " Jupiter " launched from overseas bases would only indirectly protect the United States, have all tended to rivet attention on the naval missile. Giving evidence recently before a House of Appropriations Committee, the Secretary of the Navy said that progress in the development of the " Polaris " had been amazing. He added that in addition to the three ballistic-rocket-firing atomic-powered submarines provided for in the current naval budget, the U.S. Navy intends asking in the very near future for emergency funds for the building of six more of these vessels. The " Polaris " is a solid fuel rocket, a stubby, shorter missile than the " Thor " or " Jupiter " which are liquid-fuelled, and has a range of between 1000 and 1500 miles. According to Admiral Raborn, who is in charge of the project and also gave evidence before the Appropriations Committee, it will be operational by 1960.

Now that, with atomic power, submarines can be built

large enough to carry and launch a 70-ton, 50ft ballistic rocket—or possibly two from platforms forward and aft—they would appear to provide the ideal deterrent for the post-bomber age. They can proceed submerged at 25 knots to anywhere in the world and launch their rocket submerged, completely free from detection by radar which cannot penetrate water. Indeed, the Flag Officer in command of the United States Atlantic submarine force is already talking of a fleet of 200 nuclear powered submarines. But vessels of this kind and size are extremely costly and are likely to remain so for several years. The general-purpose nuclear-powered submarines now being built in the U.S.A. are much smaller and less costly than the "Nautilus"—2200 tons and £15,000,000 as compared with her 3200 tons and £30,000,000. Their reactors are smaller and will not give the output of the "Nautilus" power plant. But the new rocket firing submarines planned will again be much larger and their estimated cost is little less than that of the "Nautilus"—to say nothing of the cost of the ballistic rocket and warhead. The main object of our Royal Navy has always been to safeguard the sea routes and even if our finances made it possible to build submarines costing well over £20,000,000 as a deterrent, there would be little money left to build the ships the Navy needs to protect our sea communications and for its tasks in a limited war. As already suggested in these columns, Britain's most effective contribution to NATO must surely be to concentrate on modern anti-submarine measures—relatively small anti-submarine submarines with small reactors, and carrier borne aircraft capable of carrying the new atomic depth charge which has now become available. But the "Polaris" rocket should be operational soon and it is intended for launching from United States surface ships as well as from submarines. It has no recoil and can be launched from almost any kind of ship of reasonable size. Given that these missiles would be supplied to us under mutual aid, there seems no reason why in this post-bomber ballistic rocket age, the Royal Navy, instead of scrapping its larger ships which can no longer be regarded as of fighting value, should not employ these vessels to provide a useful contribution to the Allied deterrent.

IMPROVEMENT IN RAIL FREIGHT SPEEDS

At a press conference last week Mr. David Blee, general manager of the London Midland Region, introduced a new express freight timetable book. It shows that out of the 7700 goods trains now run by the London Midland each day some 500 are expresses, sixty more than a year ago. This change, said Mr. Blee, was only a modest beginning. Modest or not it is certainly welcome. Indeed, if the railways are ever to recover traffic from the roads it is essential that the number of express freight trains should be rapidly increased and that traders should know their timings. Mr. Blee went on to refer to certain aspects of the modernisation plan, more particularly those likely to improve the handling of freight. Under that plan, for instance, there is to be concentration of sundries traffic at a number of freight terminals, amongst them Liverpool, Birmingham, Manchester, Watford and Stoke; new marshalling yards are to be built at Carlisle and Swanbourne; a much increased number of freight vehicles are being equipped with vacuum brakes and the construction of ten maintenance and repair depots is projected; four-aspect colour-light signalling is being installed on lines with heavy traffic, capable of permitting express freight trains running at full speed to follow one another at four-minute intervals; and so on. Additionally to speed the collection and delivery of goods, the number of containers is being rapidly expanded and the mechanisation of the cartage fleet has already been completed. Mr. Blee claimed that no other form of freight transport could match British Railways for speed.

But welcome though it is to hear about the improvements now beginning to be rapidly made under the railway modernisation plan we cannot help wondering, when we hear claims like that made by Mr. Blee, whether railwaymen are not unduly complacent about the eventual outcome. That railways are suitable for bulk transport, for example, is unquestionably true. But the idea which many railwaymen seem to hold that road vehicles are not suitable for bulk transport is strongly open to doubt. That goods can be conveyed by rail from a London terminus, let us say, to a Birmingham terminus more rapidly by rail than by road is also undoubtedly true at the present time. But is there so very big a difference in the time interval from collection point to delivery point? Where does the advantage lie when the collection point and the delivery point are less conveniently situated in relation to the main line along which the express freight train runs? Furthermore railwaymen tend to think too easily in terms of modernised railways competing with a road system much as we know it to-day. But—though much too slowly—the roads as well as the railways of this country are being modernised. Within two years the people of this country will for the first time begin to gain experience of the speed and carrying power of a substantial length of motorway. We confidently expect a much more general public demand for a rapid extension of motorways. When the railway modernisation plan approaches completion a startling transformation will have been wrought. The railways will unquestionably be far more efficient carriers of goods and people than they are now. But the building of motorways may produce consequences just as startling in the carriage of goods and people by road. Railwaymen can justly feel proud of the improvements they are making—but not too proud! Future prosperity for the railways is not assured. Railwaymen should remember that it is very unlikely anything will be allowed to prevent the building of motorways to serve all parts of the country. It is with road vehicles on motorways that modernised railways will need to compete.

CLEAN RIVERS AFTER CLEAN AIR?

Now that there is a Clean Air Act in the statute book, an Act which promises to become really effective over a term of years in ridding the air over this country of smoke, is it not time to consider whether there should not be a similarly effective Act designed over a term of years to rid this country's rivers of pollution? For the pollution of rivers has never been tackled wholly satisfactorily by legislation. Despite all the Acts that have been passed the only fully effective method of bringing a recalcitrant polluter to court is still apparently to appeal to Common Law. The trouble largely lies in a public apathy based upon a lack of understanding whence the pollution comes and of its serious effects. In the public mind (if any but anglers think about it at all!) the villain of the piece is assumed to be industry, and it is certainly true that there is much industrial pollution of rivers and estuaries. But much of this pollution is customary in the sense that it has gone on for years, so that the river concerned is already filthy and there seems to be no point in expending money on a treatment plant; and for much more the understandable argument can be

used that the public prefers cheap goods to pure water, an argument that boils down to the idea that goods are an economic necessity of our modern civilisation, whereas a pure river is merely a pleasant amenity. But, in fact, the public at large is responsible for a large amount of the pollution, a much larger amount than it appreciates. There is here a curious parallel between air and water pollution. For before the Beaver report made it clear that the domestic user of fuel was responsible for about half the smoke it was also assumed of air pollution that industry was the main villain. In fact, perhaps because there is nothing vote-catching about an extension to a sewage works, local authorities, by extending house-building and improving water supplies, are often guilty of seriously overloading the sewage plant. Moreover, this lack of attention to sewage works is covertly welcome to any Government which, like the present one, is intent upon reducing public expenditure without too obviously affecting the living standards of the electorate. The kind of result that can follow when carried to extremes is illustrated by the condition of the estuary of the Tyne, into which and into whose lower tributaries, it is reported, some 11 tons of untreated sewage are poured each day. What seems to be needed is a really full investigation of the harm done by water pollution. The situation is not to be simplified merely into terms of anglers protesting against industrialists. It is far more complex. Water pollution and water supply, for example, are interconnected. London can only draw an abundant and relatively cheap water supply from the Thames because the Thames Conservancy prevents undue pollution of that river. How much does water pollution cost in forcing up the cost of water supplies ? Again how much does the loss of salmon fisheries in, for example, the Tyne, cost as against the cost of sewage treatment ? How much fouling and corrosion of ships and waterside structures, if any, can be traced to pollution ? What are the hazards to public health ? And to the health of cattle ? Can one set a cost against them ? How many firms and at what cost have to purify their water supplies before they can use them for process work or need to draw water from the mains instead of using water direct from a river ? Despite abundant rainfall it is becoming more and more difficult to secure adequate and clean water supplies for cities and industries in this country. To what extent is pollution a cause of the shortage ? We need a Sir Hugh Beaver, or someone like him, fully to review the matter and to put the issues simply, completely and clearly before the public. He might perhaps find that it is cheaper to a nation to have pure rivers than to pollute them, just as Sir Hugh showed that it is cheaper for a nation not to pollute its air.

STUDYING FARM MACHINERY

Ever since this journal was founded, it has regularly noted and commented upon those activities of the Royal Agricultural Society of England which are concerned with farm machinery. In recent years the Society's interest in machinery has been concentrated mainly upon the show that it organises annually and the occasional competitions that it promotes for particular items. We are, therefore, glad to learn that the Royal Agricultural Society has established a machinery study group to enable its members " to study the more efficient use of agricultural machines for different purposes and new methods of mechanised farming." The study group will organise field meetings at which members of the Society will be able to see different kinds of machines at work and join in discussions afterwards. These meetings are to be held on the farms of the Society's members, and the members themselves are being invited to suggest subjects suitable for demonstration in their particular areas. The first subject likely to be studied is traction and others contemplated include irrigation, mechanical handling systems, bale handling and hauling, silage making and mechanised aids to livestock feeding.

The work of this study group can undoubtedly be of great value in the business of mechanised farming. To bring the makers and users of machinery together is a worthwhile exercise. Farmers still have something to learn about the handling of the many machines designed and manufactured for them by engineers, and engineers do not ignore the criticisms levelled at their products by farmers, however trenchantly those criticisms are sometimes expressed ! In establishing its study group, the Royal Agricultural Society—which is among the oldest of this country's learned societies—is maintaining a long standing tradition. During the 120 years of the Society's existence it has held many famous field meetings and has thereby furthered the practical application of engineering science to agriculture. So long ago as August 1856, for example, there was one of these meetings near Colchester at which reaping machines were " severely tested." On that occasion, " at the close of the experiments about 300 persons sat down to a sumptuous cold collation " and no comments on the performance of the machines appear to have been made until " justice had been done to the repast and to the usual loyal toasts." The field meetings to be planned by this new study group may not reach the same heights of conviviality as some of their predecessors a century ago, but their technical worth may well be much higher in a day when efficient agriculture is increasingly dependent upon efficient engineering.

The Engineer — 100 Years Ago (MARCH 12, 1858)

" Proposed Metropolitan Railway "

" An attempt is now being made by a very long and very earnest appeal to revive a scheme, supposed to be long since abandoned, for forming a railway through the metropolis between Paddington and the Post Office. . . . The general features of the proposed scheme are that the line shall commence at Paddington by an independent terminus, immediately opposite the Great Western Hotel, and proceed to King's-cross, where it will take a direct course to the prison in Coldbath Fields, which is to be removed. The line will then enter upon a large open space, which has been recently uncovered by the City, and will then cross Smithfield to St. Martin's-le-Grand and the Post Office.

" The entire length of the line will be a little over four miles, two miles of it passing beneath the New-road, only one mile of ordinary house property being interfered with. Sewers are to be formed under the railway, the gas and water pipes remaining as at present ; and after the railway is constructed, and the works covered in, the surface of the ground will be let to reduce the expenses of construction. The railway is proposed to be constructed with a double line of rails—both broad and narrow gauge, and the arcade through which it is intended to pass is intended to be ' spacious, dry, and well ventilated and lighted.' . . . Upon the whole, looking to the great wants of the metropolis, we believe some such scheme as that proposed by the construction of the Metropolitan Railway may answer both commercially and otherwise ; but it is a grave question, taking all matters into consideration, whether any line constructed through London, and suited, as it must be, for a very large traffic, should not be constructed above ground, and in the light of day. Considering what iron is capable of when judiciously used, surely it would be possible to construct a railway for light trains on something a little more sightly than the Greenwich arches. It would also, we believe, be quite possible to avoid the thunderings of a passing train, and so render the spaces beneath the railway suitable for shops, if not for habitations. An open space left between the railway and the tops of sub-structures, would do much, if not all that would be required, in this respect."

Postgraduate Instruction for Practising Engineers

By M. L. MEYER*

Increasing interest is being shown by industry in the various postgraduate courses which are being arranged by universities in this country. The courses to which the author of this article refers are those specifically intended for engineers who have already established themselves in industry and who wish to extend their knowledge within more or less well-defined fields. The author illustrates his discussion of the virtues of such courses by reference to the work of the Postgraduate Department of Applied Mechanics at Sheffield University. But, in fact, the discussion is relevant to the similar work of other universities.

THE technologist, in the ordinary course of his studies, is introduced first to science, later to the craft side of engineering. During a graduate apprenticeship of two to three years he will find it difficult to keep up with scientific advance in his field. The sandwich course and intermediate courses for the technician who wishes to raise himself to a technologist avoid this particular difficulty. Whichever the training, the newly trained technological engineer settling down to his job usually cannot easily keep a balanced point of view of the relative importance of both science and craft in his special field, and, more particularly, of their changing relationship as science supersedes craft (e.g. by automation), or as new crafts of importance arise (e.g. non-destructive testing). He is supposed to acquire the necessary knowledge without further guidance and amid the hurry and pressures of day-to-day routine, and on the whole makes a good job of it on the basis of a training received a number of years previously.

Nevertheless, certain disadvantages make themselves felt ; for instance, the introduction of changes in a settled routine is a precarious business, requiring human tact and confidence that the change is not only an essential but also a far-reaching improvement. One cannot keep on changing for the sake of slight improvements. The technologist must convince first his superiors and then the workers affected that his suggested improvements are, in fact, of great value to everybody concerned. Such a confidence is not easily won by learning without guidance, and in this respect our competitors from abroad may have an advantage in entering their jobs directly from a longer, more specialised training so that their guided knowledge in their chosen field is more comprehensive and more up-to-date.

The British answer to this foreign challenge has proved to be the development of postgraduate courses of instruction at many universities and colleges of technology. After initial difficulties due to an understandable reluctance on the part of industry and to doubts whether the advantages of having a member of staff trained in a professional establishment would outweigh the disadvantage of his temporary absence from duties, the postgraduate courses have grown in number, strength and popularity, in their six years of existence ; they are now recognised as an essential part of engineering education by both Government and industry. They have several important advantages over the Continental system of long specialised instruction before starting a job.

The courses are devised specially for the needs of practising engineers and are free of the need to fit into a comprehensive pattern of long-term education. Even where single lectures or subjects coincide with those of the undergraduates' last year, the separate organisation and syllabus of the postgraduate departments ensure that the courses are not just extensions of academic undergraduate teaching. A large majority of their students are practising engineers from many firms throughout the country, not necessarily all graduates, working in different fields, but having certain problems in common, namely those dealt with in the courses.

Many and varied interests thus find occasion to intermingle with useful exchanges of viewpoints and experience, not only because of the different branches of engineering represented in any one course, but also because the practical non-graduate of long standing experience is admitted alongside the theoretically inclined specialist in research or development. The only and obviously rational criterion for admission to any course is whether a man is fully capable of profiting from the instruction offered.

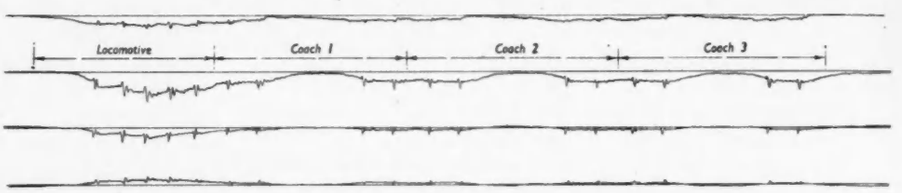

Fig. 1—Bending stresses induced in a cross girder of a railway bridge by a passing passenger train (class "41200" locomotive, with three coaches). The speed of the train was 30·5 m.p.h., as calculated from locomotive axle distances and paper speed of the record. The pronounced peaks of the traces show the impact of each locomotive and coach axle at a rail joint just above the cross girder. The highest peak (under the third locomotive axle) corresponds to only 1·3 tons per square inch stress and proves the ample safety margin of the structure

A minority of students enter postgraduate departments directly from graduation in order to learn more about special problems relevant to engineering practice and to undertake research in some of these problems, as do some of the students delegated from industry for special research in connection with the chosen course. These students usually attend courses over a full session or work on their research project in the department alongside the other students attending perhaps shorter special courses ; they contribute a valuable element of continuity and communicate to the other students an overall picture of the aims and interests of the department. The consequent mixture of practical and academic viewpoints, with a bias towards scientifically advanced methods needed in practice, is the distinguishing feature of the postgraduate departments.

A few years in a professional career may not produce the assurance of an expert, but they will give direction and aim to the young technologist, and these more than anything else are desirable in a student enrolling for postgraduate study. The aim of postgraduate study is not the passing of examinations or the testing of specialised knowledge, but an increase in the professional aptitude of each student and a more widely founded interest in his job and its problems.

If a student has direction and aim in his envisaged engineering career, he will be able to judge the usefulness of new information by thinking immediately of possible applications to the work he is doing in practice. He is sifting the information himself to the best advantage of his firm and himself and does not need the spur of an examination, at this stage always somewhat incongruous, in order to extract the essentials from a necessarily complex study. In conversation with other students he will be able to see his problems from other points of view and find new and refreshing solutions. Being in the academic community of a university or college, he is free to consult experts in other fields of importance to his work and will find advice gladly and freely given without the hindrances that often, and sometimes necessarily, beset a similar search within an industrial organisation. Problems facing him in his industrial work can be discussed in the course and possibilities of solution pointed out.

Alternatively, the student may prefer to work during the course partly or mainly on his own problem under academic guidance and, if possible, return to his firm with the solution or at least part of an answer. The firm when sending a member of staff may specifically put to him certain problems requiring urgent treatment, or a past student may return to discuss special new problems or call in the advice of the academic staff whom he has learnt to know.

The intentionally small classes (not more than about twenty students are admitted to any one class) guarantee a considerable flexibility in the arrangement of the courses and allow the lecturer to attend to the individual response of the students. The details of the subject matter and the extent to which technical problems are discussed can be varied according to the wishes expressed by students before or during the course or even in the lectures, which sometimes take the form of a many-sided discussion led by the lecturer and of an exchange of experience.

A better idea of the general working of these postgraduate instruction courses may be gained from a description of a few concrete examples. These will be taken here from the experience of the Postgraduate Department of Applied Mechanics in the University of Sheffield with which the writer is connected.

Mechanics is basic at least in some measure to most branches of engineering. Its simplest principles are well worth repeating at intervals, for practical experience does not supersede them but increases their significance and shows new aspects of their importance and possible application to the job in hand. A postgraduate course teaching a selected first- or second-year undergraduate syllabus

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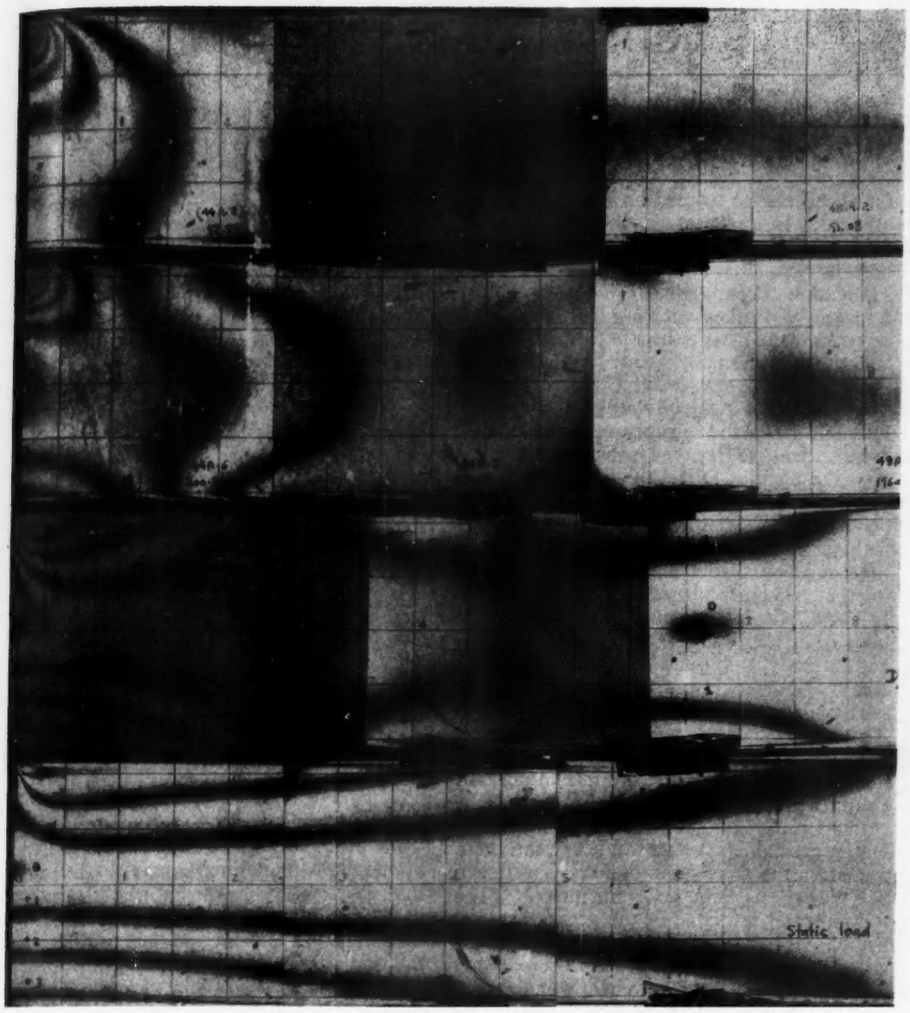


Fig. 2—Stress propagation in a clamped photo-elastic model beam impacted transversely at the centre. Composite photographs taken 90, 200 and 320 microseconds after impact and (bottom) the stresses under a static load. The loading point is at the top extreme left for each photograph. Dimensions of beam 2¼in high, 24in long, ¼in thick

with strict application to practical problems may well find good support from industry. A managing director who once promised that he would send every available man to a course on "common sense" or "horse sense" might well have had in mind this conscious application of simple principles to practical experience, a far-from-common but probably teachable aptitude. The courses in the Sheffield Department keep this need in mind in their way of introducing a subject as well as during its expansion.

However, since engineering problems can never be entirely reduced to textbook formulation, it is necessary to measure in order either to check the validity of a theory or to deduce accurate results. A whole gamut of analysing, measuring and detecting techniques are available nowadays for mechanical investigations, and with these techniques most of the courses in Applied Mechanics at Sheffield University are partly or even wholly concerned; typical courses are those on vibrations, experimental stress analysis, electronics, photography, non-destructive testing. Some courses are chosen from subjects that an undergraduate engineering student learns more as a side-line or as a small part of a larger general course but that he is almost sure to encounter many times in his practical activities, e.g. friction and lubrication, gearing, metallurgy.

The single courses vary in length from one to five weeks. Taken together they give in a full session an intensive survey of the general field of investigating techniques available to the modern mechanical engineer and they acquaint the student with certain ancillary subjects of importance to his work so that in his industrial activity he will be able to make rational decisions involving technical and economic aspects of these matters and techniques. The time tables are so arranged that a student whilst doing all the prescribed work in any particular course may also attend all the lectures in a concurrent course.

It is most important that a student should have the freedom to choose his lectures and laboratory experiments, apart from those he may have been instructed to attend by his sponsors; for at the age he undertakes post-graduate study he can be trusted to be a sound judge of his requirements in relation to his industrial job. The freedom of choice also extends to his selecting particular experiments from each of the two simultaneous courses or even particular problems, not necessarily included in the course work, for more intense study by reading or experimenting (as far as the facilities of the department allow). Because of the small number of students, full consideration and help can be given to such choice.

A short list of headings of the courses arranged for the session October, 1957, to May, 1958, will best demonstrate the range covered and aims pursued by the department:

	Weeks
Stress analysis:	
Static	5
Dynamic	2
Gearing:	
Design	5
Precision and performance	3
Loading, stress and life	3
Vibration and noise, analysis and design	5
Friction, wear and lubrication	5
Introduction to servo-mechanisms and control	5
Hydraulic operation and control of machines	2
Plasticity, fatigue and corrosion	4
Photography for engineers	2
Electronics in mechanical engineering	5
Introduction to metallurgy for engineers	2
Fine measurement in mechanical engineering	3
Non-destructive testing methods	1

Methods even more than subject matter characterise the teaching work. The Sheffield department tries to bring industrial problems into the course as a demonstration of principle in lectures, as examples of evaluation for set problems of calculation, and as "laboratory" practice. A mobile laboratory equipped for static and dynamic stress analysis, photography, vibration and noise analysis very considerably enlarges the range of practical experience the students may expect to gain from the courses. During the last session, the stresses in a railway bridge were investigated with strain gauges and a Kelvin-Hughes recording gear operated from an independent power source in the mobile laboratory (see Figs. 1 and 4). British Railways obligingly made their standard loading truck available for calibration tests. The whole department assisted in affixing the gauges and wiring up in record time; selected parties then went out on various days to take readings of stresses due to passing trains. The results were put down in a comprehensive report communicated to British Railways and handed to each participating student as a record of the investigation and reference for any similar work he may be called upon to direct.

Problems brought by industrial firms and projects already investigated or under investigation by research students may be another useful source of course work for the post-graduate student. Fatigue failures in bending of crankshafts gave rise to a comparison of available methods of measuring the strain in fillets when a static load imitating the gas pressure is imposed on the crankshaft. Students can now estimate the relative merits of two-dimensional photo-elasticity (see Fig. 2), frozen-stress three-dimensional photoelasticity, and short gauge-length extensometry for this purpose. Friction and wear tests, impact

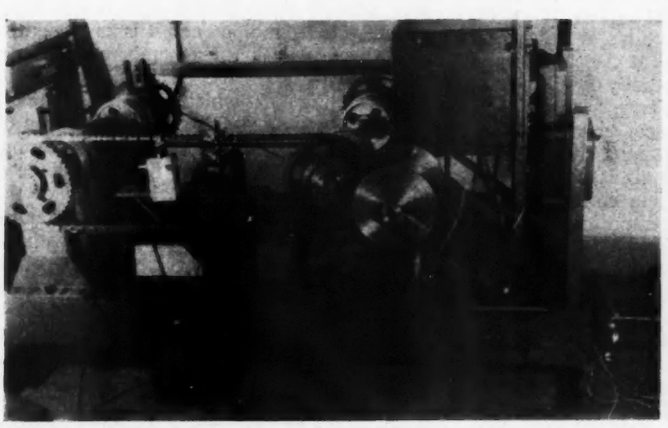


Fig. 3—Apparatus for observation and measurement of transverse vibrations of a power chain under oscillating tension. The natural frequency of vibrations is measured for varying speeds and static tensions of the chain

phenomena, vibrations of stiffened plates, dynamic loads on gear teeth can be observed and evaluated under the guidance of the research students occupied with these problems. Obviously a complete investigation as required under industrial conditions would be beyond the possibilities of any useful course of study, but the student should grasp and note down the principles and techniques of such research, evaluate specimen tests and records, and, above all, obtain an idea of the complexity and time required for the practical execution of even a seemingly simple investigation.

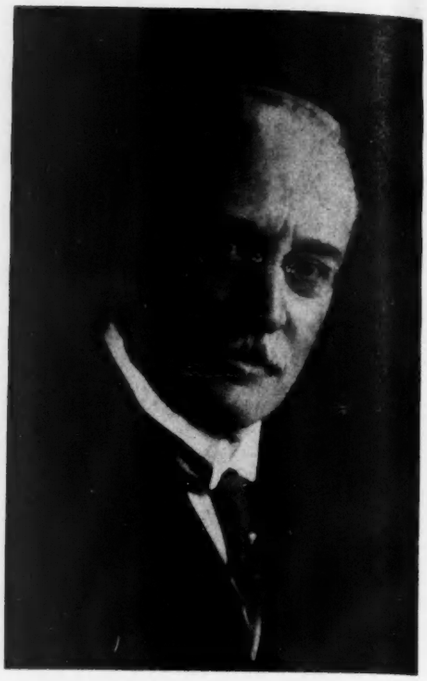
Short intensive courses must always rely to some extent on set experiments demonstrating the principles explained in the lectures, such as the pressure wedge of hydrodynamic lubrication made visible in transparent "Perspex" bearings, the observation and recording of vibrations and impact (see Fig. 3) by strain gauge or inductive pick-up and oscilloscope, the calibration of strain gauges affixed by the student himself, the propagation of stress waves recorded photoelastically, the load fluctuation in gear teeth at various speeds, the characteristics of given servo-mechanisms. Nevertheless, in all these experiments the application of principle and

Fig. 4—Preparation and affixing of wire-resistance strain gauges and extensometers to a main girder of a railway bridge

method to problems of practice is made as evident as possible, and this treatment distinguishes the postgraduate course from the more general treatment given in undergraduate courses. The aims are always to clarify the principle and at the same time to survey the available methods of application, supervision and measurement, to judge the commercial and technical merits of each method in the simplest and cheapest form that satisfies industrial needs or in a more advanced form obtainable commercially or specially developed for more delicate use in a laboratory.

The fact that the majority of firms who have once sponsored students for postgraduate courses are continuing to send members of their staff may be taken as sufficient evidence that these courses successfully fulfil the aims set at their foundation and provide for a need of which industry is aware. It is, however, still desirable that a much wider range of engineering firms and institutions should use the facilities of postgraduate departments.

Rudolf Diesel Centenary



THE word "diesel" has become so familiar in all languages and industries that it may surprise some of the younger among us who regard it merely as a name for an oil engine to read how its current use originates in an event which took place on March 18, 1858, the date on which there was born in Paris (Rue Notre-Dame de Nazareth, 38) Rudolf Diesel, son of Theodor Diesel a maker of leather goods. The year 1858 saw the launch of the "Great Eastern" and the invention, by Henri Giffard, of the injector. A year later Charles Darwin published the *Origin of Species* and George Pullman built the prototype Pullman car. A coincidence to be noted is that a few months after the birth of Diesel the first oil well was drilled in the United States, thus affording proof of the occurrence of oil reservoirs within the earth's surface. It was at this time, moreover, that the commercial success of the Bessemer process was established. In 1858 Nicolas-Leonard-Sadi Carnot had been dead for twenty-six years and Clausius had already published his paper "Ueber eine veränderte Form des zweiten Hauptsatzes der mechanischen Wärmetheorie." Redtenbacher had written his prophetic letter to Zeuner in which he remarks how "Das Grundprinzip der Dampfbildung und Dampfbenutzung sei falsch .... in hoffentlich nicht zu langer Zeit werden die Dampfmaschinen verschwinden wenn man nur erst über das Wesen und die Wirkungen der Wärme ins klare gekommen ist." (The fundamental principle of the generation and use of steam is wrong .... it is to be hoped that steam engines will disappear in a not distant future, as soon as we really understand the nature and action of heat). So far as relates to the position reached by the internal combustion engine, James Robson completed, in 1859, a horizontal gas engine of atmospheric type, double-acting, ignition being effected by electric spark on the "make and break" system. In 1857 Barsanti and Matteucci had invented the free-piston gas engine.

Particulars such as those given above convey some idea of the scientific and technological climate at the time of Rudolf Diesel's birth in 1858 and to an engineer in practice a century ago the steam engine must have appeared to occupy a more or less settled pre-eminence. Indeed, it was a famous and witty engineer of about that period who remarked, facetiously, that when the last trumpet came to be blown it would be blown by steam. Predictions of this sort ignore the onward march of time, science and technology and it is as a scientist that Diesel is best remembered. When forty-two years of age he wrote a letter to Professor Zeuner which reveals both his mind at the time (1900) and the direction to which his scientific meditation was leading him. Diesel tells Zeuner that it had been his endeavour, since "the beginning of the eighties," to arrive at "means to realise technically the supply of heat, without production of internal work, so that from a theoretical point of view, a maximum heat efficiency could be obtained ..... For a long time I believed that an approximation would have to be strived for by superheating vapours, and for several years I worked in this direction." Later, and following study of the first volume of Zeuner's *Thermo-Dynamics*, he was "induced to try the solution of the problem of maximum heat utilisation no longer by superheated vapours, but by air or direct combustion." Doubtless the most authentic exposition of the manner in which Diesel proposed to arrive at the attainment of maximum heat utilisation is the one set forth in his application (filed on February 27, 1892) for German patent No. 67,207 and in his patent No. 82,168 of 1895. The mental and physical sweat which may need to be expended in evolving a practical machine from a patent specification is, of course, unpredictable. In the case of Diesel's patent the trials which commenced in July 1893 did not terminate until January 1897. Even then it took all the courage and technical skill of the Maschinenfabrik Augsburg, stimulated by the dynamic enthusiasm of Diesel to arrive, later, at the first "serviceable and marketable Diesel engine."

Forty-six years have elapsed since Diesel (then aged fifty-four) read a notable paper before the Institution of Mechanical Engineers under the title: "The Diesel Oil-Engine and Its Industrial Importance, Particularly for Great Britain." Very interesting it is to re-read this paper and the discussion thereon since views expressed by representative engineers nearly half-a-century ago can now be tested against the facts of practice. Specially noteworthy are the observations made by Diesel himself regarding engine type; his insistence on the supreme value of experience and his advice regarding lubrication. Reading this paper to-day, together with the author's reply to the discussion which followed its presentation, we are able to appreciate the width of vision which he possessed and the part played by his prescience plus his enthusiasm. These are the qualities by which he will be remembered and a typical instance is found in his paper before the Institution of Mechanical Engineers where, after describing the use made of earth-nut and other vegetable oil, he writes as follows:

"The fact that fat oils from vegetable sources can be used may seem insignificant to-day, but such oils may perhaps become

in course of time of the same importance as some natural mineral oils and the tar-products are now. Twelve years ago the latter were not more developed than the fat oils are to-day, and yet how important have they since become. One cannot at present predict what part these oils will play in the colonies in the future. In any case, they make it certain that motor power can still be produced from the heat of the sun, which is always available for agricultural purposes, even when all our natural stores of solid and liquid fuels are exhausted."

Reading this paper and other of Diesel's writings we may recall a passage in Goethe's *Essay on Experimentation* where the philosopher remarks that "The artist may be well advised to keep his work to himself till it is completed, because no one can readily help him or advise him with it .... but the scientist is wiser not to withhold a single finding or a single conjecture from publicity." This was certainly a procedure followed by Rudolf Diesel.

It is not appropriate, on the occasion of the centenary of the birth of a justly famous engineer, to enlarge on the extent to which, unknown to him, some of his ideas may have been anticipated by earlier inventors. Rudolf Diesel would have been the first to acknowledge the importance of the contributions made by others and to affirm the justice of Voltaire's famous declaration: "On doit des égards aux vivants; on ne doit aux morts que la vérité." Remembering, therefore, the work accomplished by other engineers it seems inexplicable that practically all piston engines burning petroleum should now be described in catalogues and sales literature as "Diesel" engines. This becomes the more inexplicable when it is realised that the compression-ignition engine as we know it to-day descends from a type of engine which was actually in production prior to the date of Diesel's patent. This is no reflection on Rudolf Diesel, who in his reply to the discussion on the paper read before the Institution of Mechanical Engineers in 1912 gave most generous expression to his indebtedness to other engineers. Moreover, at the time of Diesel's death (September 1913) the use of air-injection engines was still standard. We read, indeed, that when—in 1913—the first Diesel-Electric railcar was put into service its 75 b.h.p. six-cylinder engine operated with air-injection. Also to be remembered is the fact that in his patent No. 67,207 (which expired fifty-two years ago), Diesel expressly differentiates his engine from all those in which "the process of combustion is left to itself." An attentive reading of Diesel's specification shows that engines in which "combustion is left to itself" are not to be regarded as "Diesel" engines, so that in the light of this specification the modern constant volume direct-injection heavy-oil engine should not be so described. The time must come when this matter of nomenclature will be straightened out by more accurate knowledge of oil engine history and of the contents of Diesel's own patent specifications. Failure to render to others the justice due to them can detract from the lustre attaching to outstanding individual performance. This implies no reflection upon Diesel, who died as long ago as 1913, many years before it became habitual to apply his name to virtually every description of heavy-oil engine. A century after his birth his name and fame are established everywhere and if a memorial tablet is to be erected on the house in Paris wherein he was born what better inscription could it bear than the words of Virgil:

Exegi monumentum aere perennius

Propulsion of Ships by Steam Turbine Machinery

By T. W. F. BROWN, D.Sc., S.M.*

A paper presented on Thursday, March 6, at the Institute of Marine Engineers before the Joint Nuclear Marine Propulsion Panel was the first De Laval Memorial Lecture, which was delivered in Stockholm on September 19, 1957. The pioneering work of Dr. de Laval on the design of geared turbines is illustrated in the paper, which goes on to discuss modern steam machinery for cross-channel steamers, destroyers and escort vessels, liners and cargo liners, and oil tankers and ore carriers. Consideration of the future development of marine turbine machinery leads to a detailed examination of the nuclear propulsion of ships, with particular reference to large tankers, in the second part of the paper, of which we publish an abstract. The properties and relative merits of five possible nuclear reactors are summarised, and there are notes on the problems of shielding and containment. Three alternative designs of nuclear power plant for a 60,000-ton deadweight tanker are given in some detail for graphite-moderated gas-cooled, pressurised water, and heavy-water-moderated gas-cooled reactors. All three are compared and the effect of fuel enrichment on the graphite-moderated reactor is illustrated.

THERE is the problem of the use of nuclear power in conjunction with steam turbine machinery. As far as the turbine machinery is concerned the conditions are necessarily considerably lower in pressure and temperature than those used in conventional steam plants, as the thermal reactors at present under consideration require relatively low coolant temperatures to ensure that the uranium fuel, whether natural or enriched, does not work through the α/β transition points.

From the point of view of the steam turbine the main problem with low conditions is one of ensuring adequate drainage in the cylinders. There are, however, very many points to be considered in any reactor system. The following section tries to clarify in outline the main features of thermal reactors which can at present be developed for marine propulsion.

Owing to the high capital cost of nuclear plant, its application could in the first instance only be considered in ships operating with a high load factor. This naturally suggests tankers, and in order to form a basis for discussion of nuclear propulsion for ships a 60,000-ton deadweight tanker with machinery of 22,000 h.p. is suggested. This is chosen as it represents a future standard size and designs of turbine machinery have already been made for this class of ship.

With three heavy fissile elements U233, U235 and Pu239, and moderators including heavy water, light water, beryllium and its oxides, carbon, organic materials such as phenyls, and hydrides such as zirconium hydride, there are already many variants possible, and if to this is added coolants such as gas (hydrogen, helium, carbon dioxide, &c.), liquid metal, light and heavy water and organic liquids, the choice of reactors is bewildering. Yet by following some guiding principles the choice is narrowed.

At present there are only three fully developed power reactor technologies in the world: Natural uranium fuel, graphite moderated and gas cooled (Great Britain); enriched uranium (in the case of the "Nautilus" stated to be "highly enriched uranium alloyed with zirconium") light water moderated and cooled (U.S.A.); enriched uranium, graphite moderated and water cooled (U.S.S.R.).

Any wide departure from these forms of reactors would require very special development programmes which rule out their use as marine reactors for some time to come.

In Great Britain it is clear that the civil programme will be largely built on the use of natural uranium for many years. Enriched fuel would be enriched either in U235 or in Pu239. Enrichment of U235 by diffusion is extremely expensive since the power required to produce nearly pure U235 from natural uranium is nearly equal to the power produced by the fissile material. U235 enrichment may only be required for first charge and plutonium extracted from spent reactor fuel may give material for subsequent enrichment. Either few diffusion stages could be used or a technique of centrifuging uranium hexafluoride would be required. Thermal diffusion and magnetic separation may also come back again for consideration. Professor Wilhelm Groth, of Bonn University, claims that enrichments up to 2 C_0 are possible by the use of a centrifuge with a reduction in power costs stated to be one-eighth to one-tenth of that for diffusion plants. Plutonium-enriched fuel should be cheaper when available as a by-product from power-producing nuclear reactors. The use of plutonium in reactors, however, is a long-term project as it has six or more phase changes involving difficult fuel element design problems. The possibility of plutonium developing a positive temperature coefficient resulting in instability in use in a reactor has also to be borne in mind.

From such considerations it follows that power reactors to be used in merchant ships are reduced to a small number as follows:—Graphite moderated, gas cooled, with natural uranium or low enrichments; pressurised water moderated and cooled, with enriched fuel only; boiling water moderated and cooled with enriched fuel only; organic liquid moderated and cooled, with enriched fuel only; heavy water moderated, gas cooled with natural uranium.

The graphite-moderated, gas-cooled reactor is based on a technology described in the series of papers on Calder Hall. With natural uranium, the critical size requires a large investment in uranium and the bulk and weight, including shielding, is such as to rule it out for marine propulsion in all but the largest ships. It has enormous potentialities, and can incorporate all changes enabling higher fuel temperatures to be used; among such developments are the use of beryllium canning and also ceramic fuel elements. There are reports of German developments using fuel elements in the shape of balls

* Director of Pametrada Research Station.

consisting of uranium carbide mixed with the moderating graphite which, if successful, would allow steam temperatures up to 980 deg. Fah. to become possible. This type of reactor embodies a technology which can develop a long way with improved inlet steam conditions for the turbine machinery as each stage is achieved. It is shown later how the size reduces with low enrichments (up to 2 C_0). The finding is general, although the designs apply to one output power.

The pressurised water reactor, although established, has reached the limit of potentialities as the pressure controls the temperature available at the heat exchanger. A separately fired superheater could be used in conjunction with the heat exchanger to give any desired final temperature. Calder Hall pressure vessel at 100 lb per square inch, 31ft diameter, required field welding of 2in plate. The Shippingport reactor, 9ft diameter, had 8½in mean thickness in the containment vessel for a pressure of 2000 lb per square inch. In addition, only enriched fuel can be used. It is, however, a compact rugged design suitable for ship use and particularly for naval use where highly enriched fuel can be made available. It has been used in the "Nautilus," the Shippingport reactor (which is a land-based prototype for aircraft carrier propulsion), "Yankee," and is to be used in the British submarine "Dreadnought" under construction. "Nautilus" has been reported as steaming 69,138 miles during a period of twenty-six months before refuelling. The U235 "burned" in this period was 2·8 lb. The commercial economy of pressure water reactors, however, is low because of high capital cost, low steam conditions, the necessity for enriched fuel and the high cost of fabricating fuel elements. Improvement in rating, thus reducing the core size, is, however, possible due to the good heat transmission with water cooling. It also involves greater hazards than the carbon-moderated, gas-cooled system. The high pressure involves greater risk of failure, especially with a volatile coolant, since "flashing" of the water could be a source of serious contamination. Hot water reacts violently with uranium and in the event of failure of the canning material the whole heat exchanger system would become highly radioactive. Effective shielding of the heat exchanger is also important as the water itself becomes radioactive in its passage through the core. These considerations require a strong containment vessel surrounding both reactor and heat exchangers.

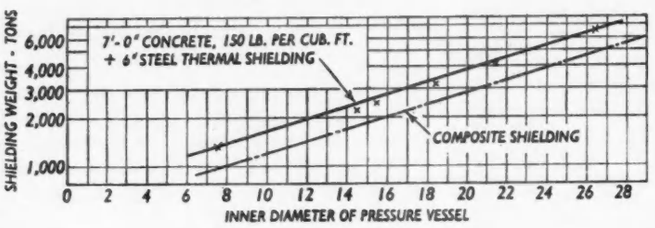


Fig. 1—Shield weights

The minimum practical enrichment for a pressurised water reactor is about 1·5 C_0, requiring the extensive use of expensive materials low in neutron absorption such as "Zircalloy." Such reactors will have a fairly large critical size, of the order of 30 tons, and this size can only be reduced at the expense of increased enrichment.

The boiling water reactor is similar to the pressure water reactor except that it can operate at a pressure of about 500 lb per square inch. However, compared with the pressurised water reactor, a reduction in power causes an increase in pressure which reduces the steam bubbles in the core, and causes an increase in reactivity due to the increase in density of the moderator. Also, the steam from the reactor going straight to the power turbine would require the machinery, including condenser and feed systems, to be shielded and introduces problems of remote control and tight shaft seals.

To reduce the high pressures used in the pressurised water reactor organic liquids (diphenyls and terphenyls or commercial materials such as "Dowtherm") have been suggested. The high boiling point of such materials enables pressures of the order of 150 lb per square inch to be used, which reduces the cost of, and difficulties in construction of, the reactor vessel and heat exchanger systems. Steam temperatures from the heat exchanger up to 600 deg. Fah. should be possible.

Considerable development work is required and the system like the pressurised water reactor necessitates the use of enriched fuel (lowest value of enrichment, say, 1·5 C_0). The heat transfer properties of organic liquids show little improvement over gas and the stability of the liquids under heat and radiation does not appear to be good. Information published gives the average breakdown rate of polyphenyl materials as 30 per cent for an integrated flux of 10^{18}. This means, in a 22,000 s.h.p. set of propulsion machinery, about a ton of make-up and the disposal of about a ton of irradiated

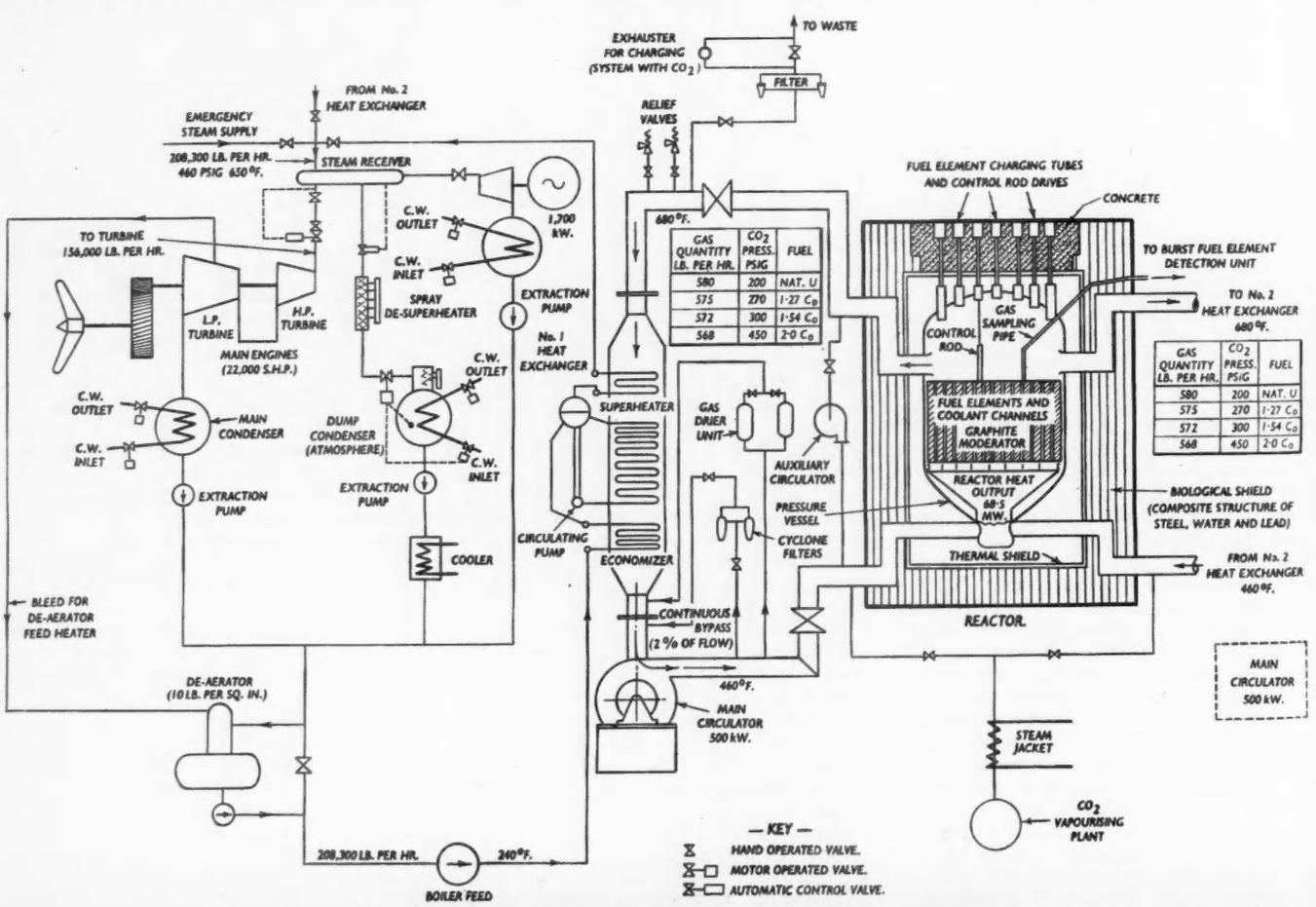


Fig. 2—Gas-cooled, graphite-moderated, reactor propulsion unit, 22,000 s.h.p.

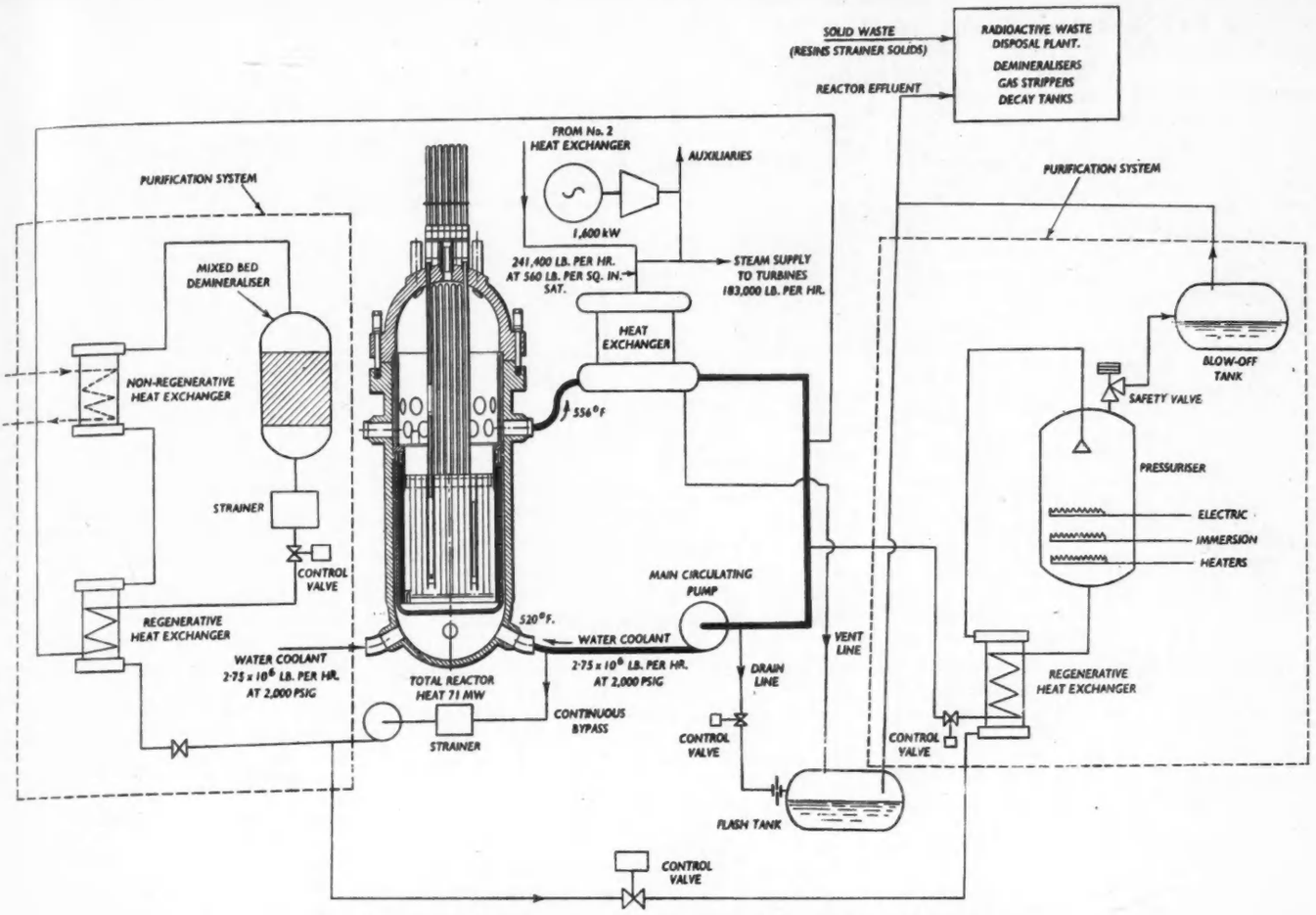


Fig. 3—Diagrammatic arrangement of coolant loop for pressurised water reactor

material per day (tars). There is a limit on top coolant temperature imposed by radiation and thermal stability of the coolant which curtails any improvement in economy which would result from high thermodynamic efficiency. Containment would also be required against " flashing." Special development as a marine reactor does not appear to be warranted.

The natural uranium, heavy-water-moderated, gas-cooled reactor is a Russian development. Heavy water acts as the moderator and the heat from the fuel elements is extracted by gas cooling. This reactor may use natural uranium as fuel and the pressures are those necessary for cooling.

The advantages of gas cooling are twofold : first, a reduction in the amount of heavy water required, and, secondly, high coolant temperatures leading to an improved steam cycle. The fuel consists of plate type elements or bundles of rods in a " Magnox " (or beryllium) tube which is assembled in outer tubes of aluminium. The coolant is CO_2 at the same pressure as that in the shell, so that the aluminium tubes do not have any pressure difference across them. For nuclear reasons the moderator must not be allowed to get too hot and the main problem is to prevent too much reactor heat passing to the moderator leading to an appreciable cycle loss and a dangerous temperature in the aluminium tube (above 230 deg. Cent.).

The reactor forms a complex source of radiation and the shield designer must approach the solution by a series of approximations. γ-rays are generated within the reactor and shield wherever neutrons are captured. The value of neutron and γ currents leaving the core are of the order of 10^{13} per square centimetre second, and attenuation of the order of 10^{10} is required to reduce this current to the maximum permissible level. For γ-ray attenuation heavy elements are best, whereas for neutrons hydrogenous materials are best.

The cheapest and most effective neutron shield is water. Concrete is cheap and effective in large thicknesses such as 7ft, but it is considered essential to reduce weight and space on marine reactors and to employ laminated shields of lead, steel and water. Sufficient is known, however, to suggest that concrete shield weights can be reduced by a factor of 0·73 by such compound shield construction, including a certain amount of boral cladding. The shield weights have accordingly been calculated on a 6in steel thermal shield and 7ft of concrete (density 150 lb per cubic foot) and the weight then obtained by multiplying the resultant weight by 0·73. Although the weight reduction, while significant, is not as great as could be hoped, it is believed that the volume reduction is considerable. These weights are plotted in Fig. 1. It will be clear how important are experiments on shielding by the use of LIDO or similar " swimming pool " test reactors for marine applications. The heat in the inner part of the shield would be removed by circulating sea water, and water in the outer part of the shield could be provided from the ballast pumping line. Cargo oil replaced by ballast when discharged might be considered for future shielding. Composite shielding consisting of concentric rings of steel plate, particularly in the outer diameter of the shielding, would represent very good armour plate against collision damage, particularly as the outermost diameter of shielding is a considerable distance from the ship's side.

In a suggested German layout to meet the requirement of containment, the weight is distributed by deep frames to the ship's structure. Apart from the reactor and containment the turbine installation is normal.

The example chosen is a 590ft tanker of 22,000 tons deadweight with a steam turbine propulsion unit of 10,000 s.h.p. at 105 r.p.m. The reactor is of the pressurised water type with enrichment not stated. The radiation shield on the reactor is 31in (800mm) thick of a lead compound filled with organic material having a specific gravity of 5. The primary circuit screen enclosing the heat exchangers is 3·1in (80mm). The safety container is 29ft 6in diameter by 41ft 6in long and weighs 900 tons. The pressurised water reactor is 5ft 7in diameter by 18ft 4in high and has a charge weight of enriched uranium of 2·4 tons. The thermal efficiency is 22·1 per cent. Professor Illies, who carried out the investigation, states that a modern steam turbine plant gives a total specific fuel consumption of 0·55 lb per shaft horsepower hour. The total weight of such a plant is 1100 tons and with a daily fuel consumption of 63 tons bunkers would be 2200 tons. Thus, engine and fuel equal 3300 tons for the conventional plant to compare with 2000 tons for the nuclear power plant.

Only two marine reactor installations are at present under construction in the world for merchant ships and both are of the pressurised water reactor type.

Mixed passenger and cargo " Atoms for Peace " ship in the U.S.A. : 21 knots ; length between perpendiculars, 587ft by beam 78ft ; draught 29½ft. Machinery installation 20,000 s.h.p. normal service, 22,000 s.h.p. overload. Pressurised water reactor has 2·9 per cent enrichment.

Icebreaker in the U.S.S.R. : size 525ft between perpendiculars by 82ft beam ; 25,000 tons gross. The propulsion turbines and generators are reported as completed at the Sergei Kirov works in Leningrad. The reactor of the pressurised water type has

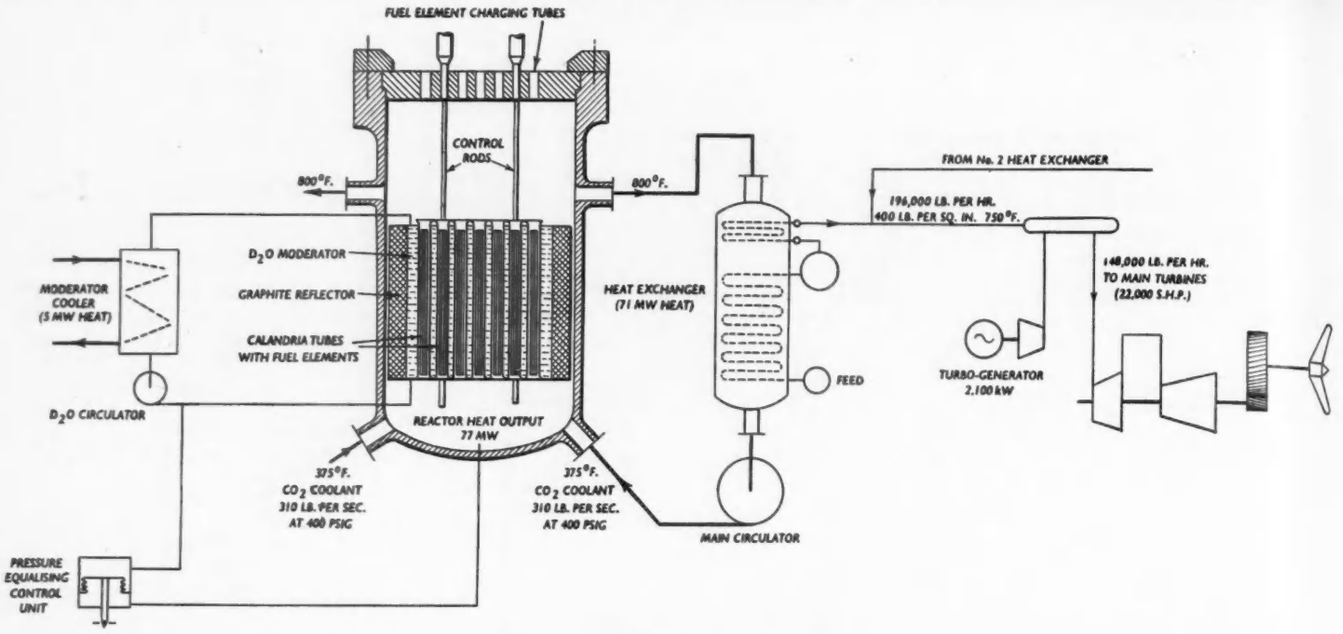


Fig. 4—D_2O-moderated, gas-cooled system

200MW heat output, of which 100MW is taken to the propulsion turbo-generators which provide a peak power of 60MW with 40MW to propulsion motors (say, 49,000 s.h.p. total on four shafts, allowing for losses). The reactor is fitted between the turbo-generator room and the aft main propulsion motors. It is stated that 78 kg of fuel will be consumed per year, the equivalent of 150,000 metric tons of fuel oil.

An attempt has been made to assess the relative sizes and technical particulars for three types of reactor which are considered practicable for merchant marine nuclear propulsion plant. The types examined are :

(1) "Calder Hall" type with graphite moderation and gas cooling in which an examination is made of the effect enrichment has on size. (2) Reactors of the pressurised water type in which enrichment is essential. (3) Examination is made of a possible heavy-water-moderated, gas-cooled reactor using natural uranium.

All the reactors have been worked out to give 22,000 s.h.p. net power at the shaft for a 60,000-ton deadweight tanker.

The ship sizes are : length overall, 790ft ; length between perpendiculars, 750ft ; beam, 107ft ; depth, 57ft ; draught, 42ft. Bunker capacity maximum 5000 tons, may reduce to 3000 tons.

The conventional steam turbine propulsion machinery has boilers fired with hydrocarbon fuel and the following particulars apply. The machinery has : normal service power, 22,000 s.h.p. ; maximum service power, 25,000 s.h.p. ; pressure at superheater outlet, 650 lb per square inch gauge ; temperature, 950 deg. Fah. ; vacuum, 28·5in ; h.p. turbine r.p.m., 4200 ; l.p. turbine r.p.m., 3100 ; main shaft r.p.m., 105 ; non-bleed steam rate, 5·55 lb per shaft horsepower hour.

Reactor Designs

Before proceeding to examine marine reactors it is considered instructive to see the particulars for Calder Hall and the latest developments arising from it.

Table I summarises the sizes and particulars of Calder Hall and the nuclear power stations now under construction in Great Britain. This table shows the trend in the use of natural uranium, graphite-moderated and gas-cooled reactors for large power production. This trend is to produce high turbine outputs and thus to depart from reactors suitable for shipboard use where horsepowers are much less. It will be seen that outputs are greater than Calder Hall and the core diameter is increased to permit of flux flattening and hence a higher mean temperature in the fuel elements. In reactors of this type for marine use the core diameter must be a minimum to reduce size and weight of reactors and shielding. It follows that the rating has to be reduced or relatively greater cooling provided.

Graphite Moderated, Gas Cooled Reactors.—Table II gives the sizes for marine reactors based on Calder Hall with increasing enrichment up to 2 C_0. This enrichment is considered to be the maximum at present as the rating has risen to more than 8MW per tonne.

Pressure Water Reactors (P.W.R.).—Table III lists the main particulars for the Shippingport and "Yankee" reactors and gives two designs for merchant ship PWR reactors for 22,000 s.h.p. and 10,000 s.h.p. output at the shaft with the minimum enrichments considered necessary for the duty. The 22,000 s.h.p. reactor could also operate at nearly double the rating (hence, of course, for half the time with a given charge) with increased cooling flows and changes in the heat exchangers. The smaller output reactor is included

Table II—*Uranium, Graphite-Moderated, Gas-Cooled Reactors*

	Nat. U.	1·27 C_0	1·54 C_0	2·0 C_0
Heat output, megawatts	68·5	68·5	68·5	68·5
Net output, shaft horsepower	22,000	22,000	22,000	22,000
Cycle efficiency, per cent	24	24	24	24
Weight of uranium, tonnes	65	28	16	8
Weight of graphite, tonnes	300	130	75	37
Rating, megawatts per tonne	1·05	2·45	4·3	8·6
Reflector, feet	3	3	2·75	2·5
Core diameter, feet ...	20	15	12·5	10
Core height, feet	20	15	12·5	10
Pressure vessel diameter, feet	26·5	21·5	18·5	15·5
Pressure vessel height, feet	64	40	36	30
Pressure vessel thickness, inches	3	3	3	4
Coolant gas pressure (CO_2), pounds per square inch gauge	200	270	300	450
Coolant gas temperature, inlet, deg. Fah.	460	460	460	460
Coolant gas temperature, outlet, deg. Fah.	680	680	680	680
Gas quantities, pounds per second	1,160	1,150	1,145	1,136
Gas circulator power, kilowatts	1,000	920	850	720
Steam conditions, pounds per square inch gauge	460	460	460	460
Steam temperature, deg. Fah.	650	650	650	650
6in steel thermal shield + 7ft concrete shielding, tons	6,742	4,102	3,272	2,486
Composite shielding, tons	4,800	3,300	2,500	2,000
Total reactor weight, tons	674	327	227	168
Heat exchanger and piping system, including blower, tons	270	314	332	426

Table I—*Leading Details of the New British Nuclear Power Stations*

Station	Calder Hall	Scotland	Bradwell	Berkeley
Authority	U.K.A.E.A.	S.S.E.B.	C.E.A.	C.E.A.
Main contractor	Several	G.E.C. Simon-Carves	Nuclear Power Plant Company	AEI-JT
Reactors × heat output, megawatts	2×180	2×625	2×540	2×550
Turbines and rated output, megawatts ...	4×21	6×60	6×55 plus 3×20 auxiliaries	4×85
Minimum sent out output, megawatts... ...	ca. 70	320	300+	275+
Graphite diameter × height, feet	36×27	50·5×28	45×31	48×30
Core diameter × height, feet	31×21	44·5×23	40×25·7*	42×24*
Number of channels	1,696	3,288	2,620	ca. 3,000
Channels per square foot	2·25	2·18	2·16	2·16
Lattice pitch, inches	8	8·25	8·00	8·16
Pressure vessel diameter, feet	37	70 (sphere)	67 (sphere)	50
Pressure vessel height, feet	70	—	—	80
Pressure vessel thickness, inches	2	3	3	3
Static gas pressure, pounds per inch	100	150	135	125
Stress, pounds per inch (pd/4t or pd/2t) ...	11,000	10,500	8,700	12,500
Blower power, megawatts per reactor... ...	5·44	12·6	—	8×2·24
Gas mass flow, pounds per hour	7·2×10⁶	20·3×10⁶	—	22·3×10⁶
Gas inlet temperature, deg. Fah.	284	392	—	320
Gas outlet temperature, deg. Fah.	637	745	—	662
Can temperature, deg. Fah.	767	797	—	—
Number of heat exchangers per reactor ...	4	8 (19·5ft×7·35ft)	6 (19ft×87ft)	8 (17·5ft×70ft)
Steam conditions, h.p., pounds per square inch, deg. Fah.	200 : 590	590 : 700	745 : 700	320 : 612
Steam conditions, l.p., pounds per square inch, deg. Fah.	53 : 340	160 : 670	195 : 700	77 : 612
Condenser vacuum, inches Hg.	28·25	28·9	28·9	29
Steam mass flow, h.p., pounds per hour ...	396,000 (77%)	1,145,000 (67·2%)	—	1,120,000 (68·3%)
Steam mass flow, l.p., pounds per hour ...	118,600 (23%)	556,000 (32·8%)	—	520,000 (31·7%)
Total uranium, tonnes	2×130	2×251	2×240	2×250
Total graphite, tonnes	2×1,200	2×2,150	2×1,910	2×2,000

* Asuming 3ft reflector.

TABLE III—*Pressure Water Reactors*

	Shippingport	Yankee	22,000 s.h.p. design	10,000 s.h.p. design
Heat output, MW	230	480	71	36
Net output	60MW (3 loops)	134MW	22,000 s.h.p.	10,000 s.h.p.
Cycle efficiency, per cent	26	27·8	23	21
Weight of uranium	12 tons	27 tonnes	30 tonnes	8 tonnes
Enrichment	Nat. UO_2 52kg of U235 alloyed with zirconium	UO_2 pellets 2·6 per cent	Nat. U 1·5 C_e	Nat. UO_2 4 C_e
Rating, MW per tonne	19	17·5	2·35	4·5
Core diameter, feet	6	6·16	5·5	4
Core height, feet	6	8·33	5·5	6
Pressure vessel diameter, feet	9	9·08	7·5	6
Pressure vessel height internal, feet	33	32·5	26	25
Pressure vessel thickness, inches	8·5	8	7	6·5
Moderator and coolant pressure, pounds per square inch gauge	2000	2000	2000	2000
Water flow temperature inlet, deg. Fah.	508	487	520	520
Water flow temperature outlet, deg. Fah.	542	529	556	556
Water flow quantity, pounds per hour	27×10^6	37×10^6	$5·5 \times 10^6$	$3·5 \times 10^6$
Pressure drop, pounds per square inch	105 (main coolant loops)	25 (through reactor)	100 (main coolant loops)	100
Water circulating pumps	—	—	1070 net h.p.	590 h.p.
Steam conditions, dry saturated, pounds per square inch gauge	600	521	560	560
Volume ratio $\frac{\text{water}}{\text{equivalent uranium}}$	—	2·8	1·5	1·1
Conversion factor	—	—	0·65	0·60
6in steel thermal shield plus 7ft concrete shielding, tons	—	—	1350	1200
Composite shielding, tons	—	—	1000	860
Total reactor weight, tons	250	250	137	40
Heat exchanger and piping system, including blower, tons	—	—	162	90

mainly to emphasise the increase in enrichment required to reduce core sizes and hence the reactor sizes for small outputs where neutron economy is difficult to achieve in a thermal reactor.

Heavy - Water - Moderated, Gas - Cooled Reactor (Al-D_2O-U).—In Table IV, the leading particulars for a projected design of

TABLE IV—*Natural Uranium, Heavy Water Moderated, Gas-Cooled Reactor*

Heat output, megawatts	77 (including 7 per cent reactor heat to moderator)
Net output, shaft horsepower	22,000
Cycle efficiency, per cent	21·2
Weight of natural uranium, tonnes	12·0
Weight of deuterium, tonnes	19
Rating, megawatts per tonne	6·5
Reflector	18in graphite, 4in D_2O
Core diameter, feet	8
Core height, feet	11
Pressure vessel diameter, feet	14·5
Pressure vessel height, feet	28
Pressure vessel thickness, inches	4
Coolant gas pressure	CO_2 at 400 lb per square inch
Coolant gas temperature inlet, deg. Fah.	375 Magnox; 400 deg. Fah. Beryllium cans
Coolant gas temperature outlet, deg. Fah.	800 Magnox; 950 deg. Fah. Beryllium cans
Gas quantities, pounds per second	620
Gas circulator power, megawatts	1·6
Steam conditions, pounds per square inch gauge	400
Steam temperature, deg. Fah.	750
Moderator	D_2O maintained at 80 deg. Cent. and externally pressurised by helium to prevent dissolving CO_2 which involves small cooler circuit and pressurising tank
6in steel thermal shield+7ft concrete shielding, tons	2,400
Composite shielding, tons	1,800
Total reactor weight, tons	141
Heat exchanger and piping system, including blower, tons	394

reactor, heavy water moderated and gas cooled using natural uranium, is given.

Cycle Data.—The diagrams showing the quantities of coolant, temperatures and resulting steam quantities, all to develop 22,000 s.h.p. at the main shaft, are shown, respectively, in Fig. 2 for the graphite-moderated, gas-cooled reactor systems, Fig. 3 for the pressure water moderated and cooled system and Fig. 4 for the Al-D_2O-U system. Some attempt has been made on these diagrams to indicate the charging, pressurising and associated systems as well as the main coolant and heat exchanger circuits. The total steam generated is sufficient for auxiliary purposes in the engine-rooms.

Fig. 6 (*a*), (*b*) and (*c*), summarises the conditions in the heat exchangers for the three types of reactors and shows that for the chosen coolant flows and temperatures steam conditions result which have a minimum temperature difference of 30 deg. Fah. at any point in the heat exchangers. It is important in the case of the Al-D_2O-U reactor that the feed temperature at entry to the heat exchanger should be low. Due to the low flux and low heat transfer rates across the fuel elements higher coolant temperature can be used. Pressures on each side of the heat exchanger can be balanced, which is impossible with a "dual cycle." The graphite moderated, gas-cooled designs, moreover, do not exceed the maximum can temperatures or gas outlet temperatures of 450 deg. and 380 deg. Cent. given by Sir Christopher Hinton. The effect of gas pressure on heat exchanger size was found to have only a small effect for both the gas cooled reactors, although in the case of the Al-D_2O-U reactor the pressure was chosen from the point of view of heat transmission in the heat exchanger. If a lower steam pressure had been used the heat exchanger size could be reduced but the efficiency of the steam cycle would have been less. If a higher pressure had been chosen the temperature difference in the heat exchanger would have been too low, resulting in a great increase in size.

From these design figures, weights for reactors, heat exchangers, piping systems, pumps, &c., were calculated, allowing the comparison of total machinery weights which are set out in Table V on this page.

The ship's load apart from reactor cooling, &c., was taken as 700kW.

Rapid manœuvring is required from time to time. Under such conditions the reactor output should remain sensibly constant as thermal cycling will seriously reduce the life of the fuel elements. This condition would be met by spill valves, passing the steam from the heat exchangers not required by the turbines by way of water sprays to a dump condenser at atmospheric pressure. As a fairly large temperature rise in the circulating water can be tolerated in an atmospheric condenser the size can be kept small.

At 22,000 s.h.p. the main condenser at 28½in vacuum, with sea water temperature of 75 deg. Fah., would have a surface of 23,600 square feet and a circulating water flow of 25,000 gallons per minute.

An atmospheric dump condenser to condense the steam flow to the turbines of, say, 180,000 lb per hour if preceded by a jet cooler would have a surface of about 3100 square feet and would be followed by a drain cooler of about 1800 square feet surface, both circulated by a pump passing 3800 gallons of sea water per minute.

With a dump condenser fitted, the basic control variable in the reactor would be outlet gas temperature from the reactor, since this ensures constant temperature working of the pressure circuit. Constant can temperature would not be so advantageous as a change in power would involve a redistribution of the temperatures within the fuel. Reactor control down to 10 per cent power should be possible but must follow the power change and not initiate it. Axial flow gas circulators with Ward-Leonard control would appear to be best, but if the cost and commutation trouble prove difficult steam turbine drive could be used. The auxiliary blower for cooling down would be motor driven, the power being provided by an auxiliary oil engine-driven generator. There could also be an emergency battery system. In the case of the PWR type, similar remarks would apply to the drive for the cooling water circulating pumps.

UTILISATION OF NUCLEAR FUEL

There are two main factors in the utilisation of uranium or enriched uranium in reactors,

TABLE V—*Complete Engine Room Weights (Steam Up)*: 22,000 *S.H.P. Installation Including Turbo-Generators*

	Oil burning installation	Graphite moderated, gas cooled				PWR system	Al-D_2O-U system
		Enrichment					
		Nat.	1·27 C_e	1·54 C_e	2·0 C_e		
Main propelling machinery	190·5	210·3	210·3	210·3	210·3	223·4	205·5
Stern gear	75	75	75	75	75	75	75
Propeller	37	37	37	37	37	37	37
Auxiliaries, 2 TGs. at 1000kW	300	—	—	—	—	—	—
Auxiliaries, 4 TGs. at 1000kW	—	360	360	360	360	360	360
Main steam	18	22	22	22	22	25	22
Cocks and valves	180	180	180	180	180	180	180
Ladders, tanks, floorplates, &c.	130	130	130	130	130	130	130
Water and oil	78	60	60	60	60	65	62
Boilers, including uptakes, economisers, &c.	440	—	—	—	—	—	—
1 emergency and cargo working boiler	—	134	134	134	134	134	134
Funnels and uptakes	52	12	12	12	12	12	12
Spare gear	54	50	50	50	50	50	50
Reactor weights	—	674	327	227	168	137	141
Shielding weights (composite)	—	4800	3300	2500	2000	1000	1800
Heat exchangers and piping (2 off each) and coolant pipes	—	270	314	332	426	162	394
Total machinery weight, "steam up," say	1560	7015	5212	4330	3870	2590	3610
Bunkers (ships)	3000	—	—	—	—	—	—
Bunkers (cargo working in emergency only)	—	800	800	800	800	800	800
Total weight	4560	7815	6012	5130	4670	3390	4410
Resultant excess weight (tons); or	—	3255	1452	570	40	—	—
Saving in weight of nuclear propulsion machinery	—	—	—	—	—	1170	150
Steam conditions	Pressure, 650 lb per square inch gauge, temperature, 950 deg. Fah.	460 lb per square inch gauge, 650 deg. Fah.				560 lb per square inch gauge, saturated	400 lb per square inch gauge, 750 deg. Fah.

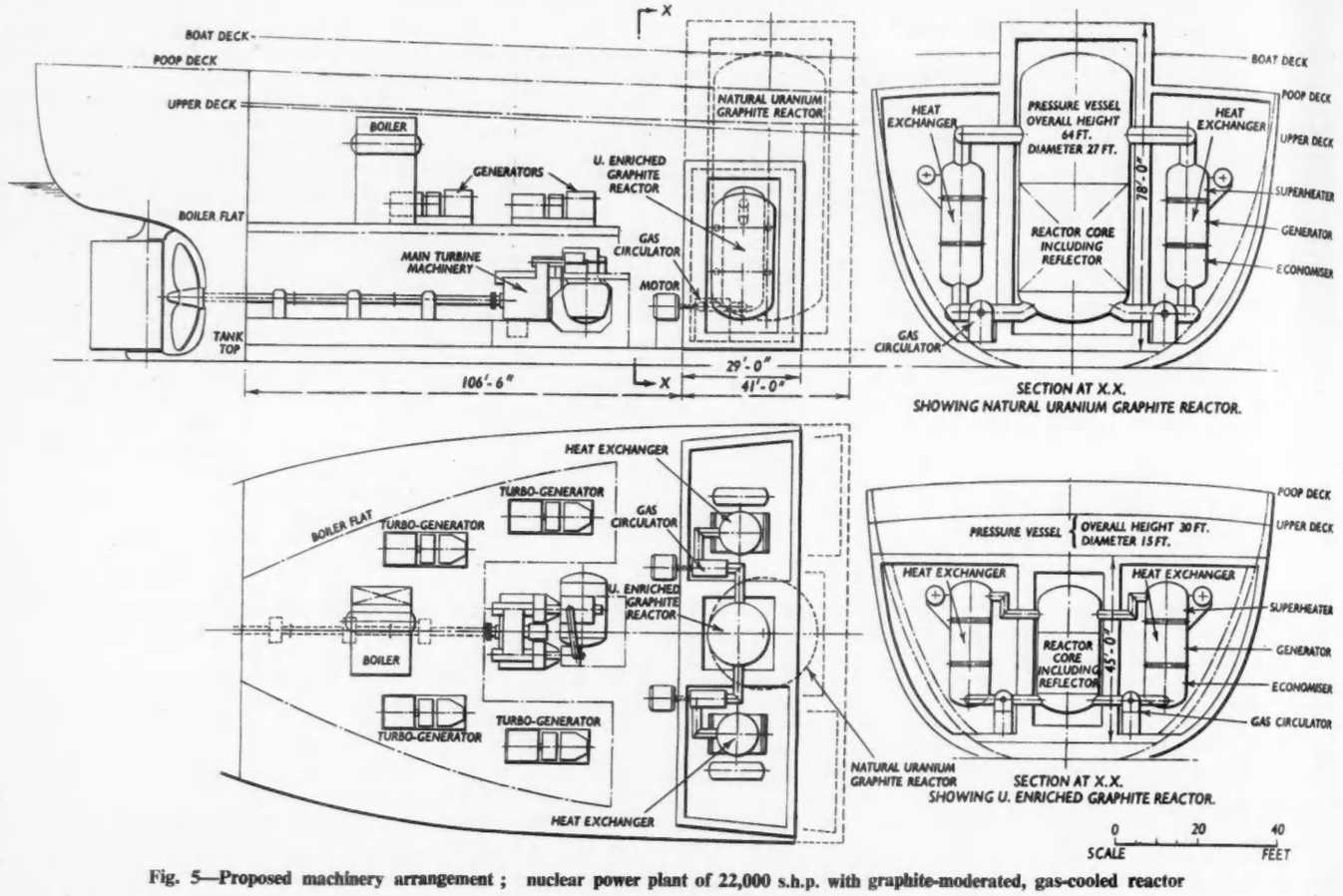


Fig. 5—Proposed machinery arrangement ; nuclear power plant of 22,000 s.h.p. with graphite-moderated, gas-cooled reactor

namely, rating and fuel element life or burn-up. Rating has been defined in the tables as megawatts per tonne of uranium. This figure is a measure of the amount of heat being given off by the fuel. Uranium has two critical points at 660 deg. and 770 deg. Cent., called the α-β points, at the higher of which considerable volume change takes place which might have a serious effect on the canning material. The maximum centre temperature of the uranium is consequently kept at about 600 deg. Cent., giving a temperature at the can of 475 deg. Cent. for a rod of about 1in diameter.

The second item, fuel element life or burn-up, is a figure which will not be known in practice until reactor cores have been run over the necessary period up to and perhaps beyond the expected figure. It is controlled by reactivity loss caused by neutron loss, to fission products additional to the transient xenon poisoning, or the fuel life may be terminated by radiation damage or corrosion. The figure for life varies with the enrichment and at present 3000MW days per tonne is taken for natural uranium and an increasing amount up to 8000MW days per tonne for 4 C_0 (2·9 per cent) enrichment by U235.

Other marine requirements can only be mentioned to keep the paper within bounds. The strength of the graphite pile under vibration and a ship's movements would require special investigation. Costs must be the lowest possible, taking into account capital expenditure, running costs and maintenance. Maximum safety is required covering corrosion, containment and collision and the controls must be designed to "fail to safe" under all operating conditions. In this connection the flow of coolant is even more important than control rods, although one of the serious hazards is the possibility, due to poor operation or accident, of a large step excess reactivity being inserted. One of the most important parameters under such conditions is the mean neutron lifetime, the

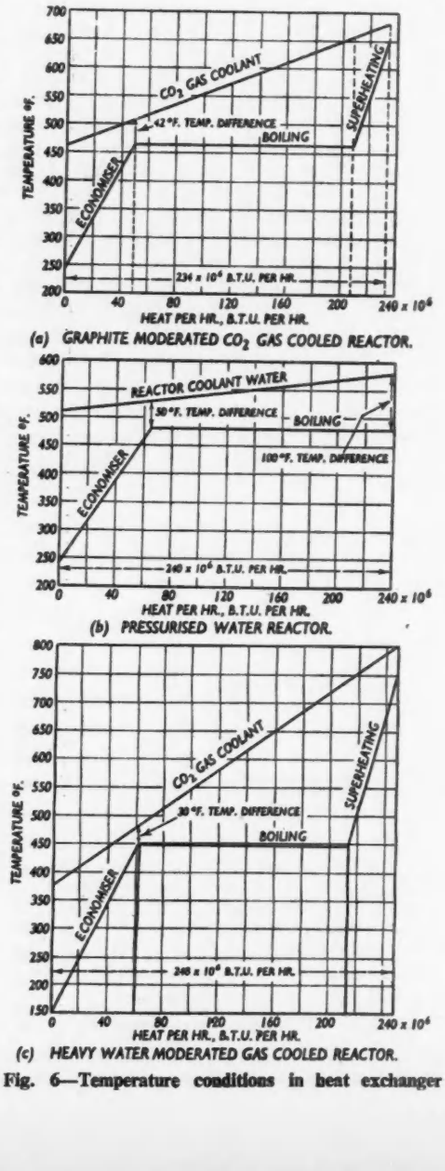

TEMPERATURE °F.
HEAT PER HR., B.T.U. PER HR.
CO_2 GAS COOLANT
42 °F. TEMP. DIFFERENCE
BOILING
SUPERHEATING
ECONOMISER
234 x 10⁶ B.T.U. PER HR.
(a) GRAPHITE MODERATED CO_2 GAS COOLED REACTOR.
REACTOR COOLANT WATER
30 °F. TEMP. DIFFERENCE
100 °F. TEMP. DIFFERENCE
240 x 10⁶ B.T.U. PER HR.
(b) PRESSURISED WATER REACTOR.
30 °F. TEMP. DIFFERENCE
240 x 10⁶ B.T.U. PER HR.
(c) HEAVY WATER MODERATED GAS COOLED REACTOR.

Fig. 6—Temperature conditions in heat exchanger

longer this time the less rapid the resulting power surge. Typical values of mean neutron lifetime are :

Graphite	10^{-4} sec
H_2O	$6{\cdot}3 \times 10^{-4}$ sec
D_2O	10^{-2} sec

The graphite reactor has a mean neutron lifetime some fifteen times longer than the pressurised water reactor and is correspondingly less sensitive to step increases in reactivity. Any temperature or power excursions resulting, however, will clearly be less severe (if temporary) in a low rated reactor with, in consequence, a relatively large thermal capacity.

Engine-Room Arrangements.—Fig. 5 shows a sketch engine-room layout of 22,000 s.h.p. for the 60,000-ton tanker. There is plenty of room for the reactor control panel on the boiler shelf. It will be seen that the Calder Hall reactor, although of minimum core diameter, projects through the upper deck, and although this may be convenient for fuel servicing, it is not good for the structure. The enriched uranium reactors, graphite moderated or PWR or Al-D_2O-U reactors, however, can be housed below the upper deck, producing a stronger ship. The aft bulkhead of the reactors would normally be the forward engine-room bulkhead for conventional steam turbine machinery, as the propulsion boilers can easily be accommodated on the boiler flat aft of the turbines. The extra engine-room length, however, is to some extent compensated for by the great reduction in bunker space.

A lot has to be done but the whole object of this outline survey is to show the feasibility of nuclear propulsion of merchant ships starting with a tanker. Enriched fuel (up to a maximum of, say, 4 C_0) is clearly of supreme importance to the future of mercantile marine reactors, whether graphite or water moderated. Failing this, the development of the Al-D_2O-U reactor should be pressed forward.

Reaching into the future, fast breeder reactors will be necessary, as they will extend the use of uranium by a factor of more than 100 and are by far the best means of using plutonium. When temperatures of the cooling gas exceed 1200 deg. Fah. the gas turbine has already been developed and research and development is proceeding up to the use of a top gas temperature of 2200 deg. Fah. Still further in time, power from thermonuclear fusion of light elements may be possible, in which case a ship is floating on an unlimited store of deuterium ($3 \cdot 8 \times 10^{13}$ tons in the oceans of the world). Future costs for nuclear propulsion will be much lower than those arising from the burning of hydrocarbon fuels, which will become scarcer and more expensive with the passage of time.

In the question of nuclear propulsion of ships we are in the position of Dr. de Laval when he started his work on the steam turbine. Many feasibility studies have been made and many more studies are under way. In difficulties, Dr. de Laval followed his own precept—"It is better to use two nut-crackers than one," and, again, when a particularly costly construction ended in a temporary check, he said: "It is on heaps of scrap iron that the road must be paved," and pressed on to success.

Siemens Centenary

By J. N. ALDINGTON, B.Sc., Ph.D., M.I.E.E.*

A lecture was given by Dr. J. N. Aldington on March 5 to mark the centenary of Siemens Brothers and Co., Ltd. Dr. Aldington reviewed the development and use of electrical energy with particular reference to the contributions made by this company. He showed how electrical communications, power and lighting started at different times in the last century and then evolved in three parallel but closely connected paths. Abstracts from the lecture are reproduced below.

IN 1843 William Siemens came to England as a young man of twenty. At first, although his elder brother, Werner von Siemens, founder of the German house, was actively working on telegraphy for military purposes, William's principal interest was in other fields, for example, electroplating.

First he tried to find a market for an invention which he had in the field of electroplating and eventually he sold his electroplating patent in 1843 to the famous firm of Elkingtons, of Walsall, Birmingham. I know of the encouragement this gave to the young Siemens and was one of the reasons which caused him to remain in this country and to found the firm which celebrates its centenary this year.

William was also interested in what is called a chronometric governor, a method for maintaining constant speed in a steam engine; and a water meter which became a matter of great commercial interest both in this country and on the Continent of Europe; and in the principle of the regenerative steam engine and the regenerative furnace. This regenerative furnace was so important in those days that it was introduced into many industries; for example, Messrs. Chance Brothers, Smethwick, Birmingham, installed a number of these furnaces for making optical and other glass. The Siemens regenerative furnace was also used for puddling iron to make it malleable and, later, for the production of steel. As the Siemens interest in the need for producing better magnetic steels developed it was decided to set up a company for the production of steel by the so-called Siemens-Martin process, and eventually a steel-making plant was established in South Wales. But all these events are not truly part of my story to-night, which is to do with electrical engineering and the development in thinking in the engineering field.

During the next few years prior to the formation of the company in 1858, William Siemens began to take an increasing interest in the electric telegraph, and this interest extended not only in the instruments for sending and receiving messages but also in the lines and cables required to connect telegraph stations together, often at distances of many miles.

* Group managing director, Siemens Edison Swan, Ltd.

William Siemens (1823-1883) came to England in 1843 and founded the firm of Siemens Brothers in 1858

The first uses for the telegraph were either for military purposes or for purposes connected with the development of the railway system. The first lines consisted of copper or iron wires threaded through insulators and carried by pine saplings which varied in length from 20ft to 40ft. At that time the telegraph exchange was unknown. The individual wires merely connected together the transmitter and the receiver.

Many ways of producing an insulated cable had been considered before this time; some, for example, by threading on to the wire pieces of glass tubing, by surrounding the wire with various insulations, and obviously the technique of rope making was closely related to that for making cable. Indeed, the first cables were really ropes with a metal wire running through the centre. For submarine work it was appreciated that a continuous hermetically sealed covering was required and a suitable substance was obtained by Siemens Brothers in gutta percha, the sap exuded from certain types of tree. By 1848 the Siemens Company had developed machinery for insulating cables with gutta percha and obtained contracts in Germany for making and laying several hundred miles. These were the first practical submarine cables, and in the same year the Siemens German company produced a seamless gutta percha insulated submarine cable and laid lengths of it in the port of Kiel for exploding mines. From these beginnings the next step was to surround the insulated core of the cable with galvanised iron wires laid on a suitable bed. In general the bed was hemp rope. These iron wires were necessary not only to protect the cable from physical damage, but to provide the necessary tensile strength. The finished cable was therefore exactly like a wire rope of to-day.

Due to the astonishing growth of interest in submarine telegraph cables in the years 1860 to 1890, Sir William Siemens resolved to design a cable ship on his own initiative, although he had no previous experience of naval architecture. With it Siemens made and laid many important telegraph cables throughout the world and by 1897 no less than seven North Atlantic telegraph cables connecting Great Britain with the American continent had been laid with this ship. In 1861 out of 11,300 miles of cable laid only 3000 miles were actually working, and the world was clamouring for cables. William Siemens determined to be among those who satisfied this demand.

The Telephone

But another revolution had, in the meantime, taken place with the invention in 1878 by Alexander Graham Bell of the telephone. Very shortly after the announcement by Bell another type of microphone was developed which, with its accompanying battery, had an amplification of about 100 times that of the Bell transmitter, and the carbon microphone, as it was called, depending on the changing resistance of carbon with pressure, was responsible for a series of remarkable developments in communications which flowed in rapid succession.

Within ten months of the announcement by Bell, the German Siemens companies had patented a number of telephone instruments, among which was probably the first loudspeaker with paper diaphragms. Thomas Alvar Edison also entered the field with characteristic energy and rapidly produced an improved carbon microphone.

In the beginnings of telephony, as had been the case with telegraphy, two instruments were connected directly together by a twin wire. The telephone transmitter and receiver were, therefore, used in precisely the same way as the telegraph key and the needle instrument which signalled Morse code at the other end of the telegraph line.

The first manual exchanges were brought into use about the year 1880 and from that time up to the First World War they underwent general development without any fundamental invention, but after the first war the automatic exchange, which had resulted in the main from the pioneer work of an inventor called Strowger, in the U.S.A., came to the forefront and Siemens took their share of the development of the high-speed switches, relays and other components for these automatic systems—systems which in these later days are of great complexity and reliability. One of the first practical installations in this country utilised the Bell receiver with a carbon transmitter and was called the

Gower Bell telephone which was standardised by the Post Office in 1880. The carbon microphone was that due to Professor Hughes first shown at the Royal Institution and the receiver was the standard Bell receiver. The principle of the telephone and its value in industry and commerce having been demonstrated, developments took place in the instruments at each end of the line, in the telephone exchange itself and in the telephone cables to connect two exchanges together.

The Gower Bell telephone with its somewhat cumbersome ear tubes survived for about twenty years but just before the beginning of the present century and lasting for the first quarter of the century, the standard Post Office subscribers' telephone became a combination of the so-called solid-back carbon granule transmitter and the long handle Bell receiver. By the end of this period Siemens Brothers had designed the "Neophone" which substantially is the telephone instrument which is known to all of us to-day and which is used all over the world. The British Post Office standardised this instrument under the name Hand Combination Set and it is the basis for all the practical designs throughout the world.

While all this was happening the company's dial, the key to automatic exchange operation, was adopted by the Post Office in 1921 and an improved version, the cam plate dial, was patented by Siemens Brothers in 1928 and adopted in 1930. This dial controlled a Strowger two-motion switch which, in the hands of Laidlaw and Grinsted of my company, underwent important developments. Immediately Grinsted and his colleagues embarked on the development of the high-speed motor uniselector switch which, with its accompanying high-speed relays, causes the operation of a switch circuit in less than one thousandth of a second instead of many thousandths of a second in use hitherto. The company's No. 17 automatic telephone system which resulted from this primary work and other engineering developments, has now been installed in many places throughout the world and is becoming standard in Australia.

Until a year or two ago the only method of speaking on the telephone to America was by radio, but by that time work which had been going on for twenty or twenty-five years both in this country and in America culminated in the manufacture of a telephone cable system capable of being lowered to the bottom of the Atlantic and to connect the two continents of U.S.A. and Great Britain not by a telegraph cable but by a telephone cable. One of the major problems which had to be overcome was that of attenuation.

The problem of making a cable, therefore, which would transmit clear telephony over the Atlantic was not only one of producing a cable of extremely high accuracy but also producing a type of repeater of such reliability that its thermionic valves at the bottom of the sea could be expected to work without failure for at least twenty years. By a joint British and American enterprise the various problems were eventually solved and the cable was opened last year.

It is interesting to record, before leaving the subject of communications for the moment, that to provide a meeting place for the rapidly growing art and science in the field of telegraphy the Society of Telegraph Engineers was formed in 1872. It became the Institution of Telegraph Engineers in 1878 and Dr. William Siemens, as he then was, gave his founder's Presidential address. As electrical science expanded during the next few years, the Institution was expanded in scope to accept papers and to form a meeting place for deliberations on many other aspects of the rapidly growing electrical industry and, therefore, the name of the Institution was changed to that of the Institution of Electrical Engineers.

Power

I want us now to take our minds back to Faraday's lecture in 1831. You will recall that in that lecture Faraday announced the discovery of what is now known as "electromagnetic induction" and he spoke of his "magneto electrical machine." It is of interest to recall that Faraday told William Siemens in a letter that he had deduced the principle of induction in 1824 but that his pre-occupation with chemistry and other scientific work had prevented him bringing about a practical demonstration of this phenomena until the years 1830 and 1831 culminating in his famous Discourse before the Royal Institution.

The steel available for magnets at that time for making magnetc-electric machines was very poor stuff indeed compared with the magnetic steel of to-day. The magnets speedily lost their magnetism, both with mechanical shock or the passage of time. Steps were therefore taken to re-energise the magnets by means of a second generator or battery. You will appreciate that the generators of the day consisted simply of the poles of a powerful magnet, or a group of magnets, with an aperture cut in the poles in which rotated an armature on which coils of wire were wound. Electric current was taken off from the armature by means of what we now call a commutator or slip rings, depending on whether rectified direct current was required or alternating current. The Siemens' factories engaged themselves in the design and production of machines of this type with permanent magnets, first of all as signal generators for their telegraph systems, and eventually for generating small amounts of energy for other purposes. Unfortunately the output of these early machines, and their efficiency in converting mechanical into electrical energy, was relatively small and the output also declined after a time due to the progressive loss of strength of the permanent magnets of that day.

In 1867, however, Siemens Brothers and others almost simultaneously, discovered that some of the current from the generator could be shunted or passed back through windings on the magnets themselves, and so the self-excited generator or dynamo was invented. Very soon they discovered that the soft iron poles would retain sufficient magnetism to allow the dynamo to build up to its designed voltage without the use of permanent magnets at all. Siemens thus began the production of the self-excited dynamo at Woolwich about the year 1870. It is now a matter of record that the Stafford Works were sold in 1919 to The English Electric Company when Siemens Brothers decided to withdraw from their heavy plant and pioneer work on power generation and application.

A stage had now been reached when dynamos were available for generating electricity and their first use was to produce light and we must remember, as I said at the beginning, that there were still no power stations or electric wiring or electric wires even, or cable, or any machines or equipment designed to be driven by electricity. Even the carbon arc had severe limitations. It was only suitable for street lighting or the lighting of large areas and it was applied as rapidly as agreements could be reached to such installations as the lighting of the Royal Exchange, the internal lighting of the Albert Hall and the British Museum. Siemens Brothers entered the field of lighting with all the accessories and developments both of the carbon arc itself and all the necessary fittings, fixtures and control units.

The time was ripe, therefore, for some major new development which would allow electric generation to take its proper place in the rapidly evolving industry of the last quarter of the nineteenth century and the event which caused a new impetus and a new urge was the development by Swan in England, and simultaneously by Edison in America, of the carbon filament lamp, in which light was produced by incandescence of a thin filament of carbon enclosed within an exhausted glass bulb. Fortunately, Swan and Edison, instead of entering into disastrous litigation, decided to join forces, and in 1882 they formed the Edison Swan Electric Company, Ltd., who developed and marketed their invention.

These developments demanded a new principle in the generation of electrical energy. The new principle was to form lighting stations as they were called—the forerunners of the present power stations—which lighting stations would supply electrical energy and distribute this energy over cables and wires to the houses of the subscribers.

It was necessary to provide some means of dealing with the variations in load on the lighting station at different times in the day and night, and, hence, the lead-acid accumulator was developed for what became known as the central station battery. It was Sir Joseph Swan who invented the preform pasted plate which is now standard throughout the world with lead-acid accumulators, and this replaced the tedious process of producing the original Planté plates by a sequence of charging and discharging operations.

The lighting station, located near to the lighting system, contained prime movers such as steam engines, or gas engines, driving d.c. generators and using an accumulator battery to take over the supply when the load fell below a certain minimum.

Among the uses of the d.c. dynamo was its reversibility—the fact that it became a motor and produced rotatory motion if supplied by electricity from another source. This discovery suggested, among other things, the possibility of electric traction, and in 1882 William Siemens designed an electric railway for Portrush in Ireland and, using two water turbines for driving his dynamo, he electrified the rails (the power being transmitted to the railway by an underground power cable) and so produced one of the first electric railway systems in the world. It is believed that the first of all such systems was that due to his brother, Werner von Siemens in Germany.

Early Power Cables

Broadly speaking, the power supplies of that time were either carried by bare wire on insulators in ducts or by power cables, but gradually power cables took over from the bare wire.

Siemens Brothers favoured impregnated jute for power cables. Later they used insulating compounds of various types and in 1883 had developed the lead press which gave a continuous tube of lead over the insulated cable core which eventually became standard for the sheathing of power cables.

In 1885 the German Siemens Company introduced the protection of the lead sheath

with overlapping steel tapes and this brought the character of development almost to modern times as the steel tape or steel wire armoured cable of to-day is essentially the same in character as the 1885 Siemens cable.

By 1889, Siemens Brothers had laid a cable of this general kind operating at 2400V for the London Electricity Supply Corporation.

By the turn of the century, the development of power transformers and cables had reached a point at which 10,000V was considered a normal voltage for power transmission lines. It was, however, clear that for the transmission of much greater power, increases in the operating voltage was essential. Ferranti provided one of the basic solutions to this problem by his development of the use of impregnated paper as an insulation for the cable, and this development led to modern types of paper-insulated cable of the solid oil-insulated paper type up to 33kV. I had a letter from Sir Vincent de Ferranti the other day in which he reminded me that his father, Sebastian de Ferranti, began work at Siemens, Woolwich, soon after he reached this country about 1883.

Siemens made rapid developments in both land and underwater power cables, and in 1928 they made and laid 83 miles of 33kV submarine power cable in Sydney, Australia. This was followed by a submarine cable across the Brisbane River and the first power cable from the mainland to the Isle of Wight.

Light

In the previous sections we have seen how interlaced have been the various influences which have affected developments in electrical technology during the last century and nowhere has this been more true than in the case of lighting.

Let us try to see the reasons which lead to the rapid development of electric lighting.

You will recall that Swan and Edison together in 1879 and 1880 announced the development of a practical small unit of light—the carbon filament lamp. This lamp operated at what we should consider to be very low efficiency—an efficiency of the order of $\frac{1}{4}$ lumen per watt. When I tell you that if it was possible to convert one watt wholly into light and that that light was at the peak of the visible spectrum of the human eye, then the efficiency would be of the order of 620 lumens per watt, one can appreciate how inefficient were those early lamps—and yet the lamp was a great invention in its time. It was followed early in the present century by the development by van Bolton of the Siemens Company of the first metal filament lamp using the comparatively rare and refractory metal tantalum.

At the same time in other parts of the world tungsten, most refractory of all the metallic elements, was being converted into continuous filaments by a process in which a mixture of tungsten metal powder and binding material were extruded through special dies and the fragile filaments were found to give lamps of even greater efficiency than was attainable with either carbon or tantalum. Soon afterwards, however, Coolidge in America showed that ductile drawn tungsten wire could be produced and this drawn tungsten wire superseded all other forms of filament for electric lamps and is still the best filament material to-day.

At first all electric lamps consisted of a filament mounted inside a glass envelope and the space within the envelope was exhausted of air. Gradually as the lamp burned for several hundreds of hours the glass bulb slowly darkened. Investigation of this darkening process to discover the reason showed that in a well made lamp the darkening was due to normal evaporation of the tungsten. Langmuir's discovery that a coiled filament behaved in a similar manner to a very short length of straight filament provided a solution in which the gain due to increased efficiency that could be obtained without material increase in the rate of evaporation far outweighed the losses due to conduction and convection and the present modern gas-filled lamp was born.

Such lamps came into general use after the end of the 1914–18 war and from those beginnings have come the whole range of tungsten filament lamps known to-day—a range which includes no less than 20,000 to 30,000 different designs.

In general, ordinary household lamps are designed for about 1100 hours. Some types of projector lamp are burnt so brightly that their designed life is only 100 hours or fifty hours or twenty-five hours according to type. It is always a compromise between producing the maximum amount of light and the maximum amount of life.

Before I leave the subject of tungsten lamps I want to mention a modern development—the solid source—in which, for example, five tungsten filaments are mounted separately in a gas-filled envelope. Because the filaments are electrically and mechanically identical it is possible for them to touch and operate as a solid source even at this very high temperature without there being any appreciable circulating currents within the compact assembly.

Recently the xenon arc has been developed for a number of very special purposes among which has been the special light sources for radar plot projection. We have a film taken within the last two or three days at the airport of Indianapolis where this type of lamp is used in radar projection equipment developed by Kelvin and Hughes. The original development was for military purposes but the equipment is now being used in airports in various parts of the world for the presentation of radar data showing the aircraft around the airport at distances up to 100 miles.

These xenon lamps can not only be used for projection purposes of the kind we have just demonstrated ; they are now being used for ordinary small film projectors to replace the carbon arc : they have been demonstrated in film projectors to show how improved screen brightness can be produced by eliminating the shutter and letting the lamp itself flash in and out to act in place of the shutter in the normal screen projector. They are being tried for such widely different purposes as film studio lighting and the lighting of television studios in connection with colour television. Their very close representation of normal daylight enables scenes to be shot either inside or outside without any change in the colour processing of either the film or the television transmitter and receiver.

Lamps of a similar type but working at higher voltages were developed during the war to produce very high brightness flashes of light for photographing missiles in flight and for aerial photography.

Such discharges of the pulse type produced by charging up a condenser to a very high voltage and then discharging it momentarily through quartz or a glass discharge tube result in extremely high peak powers—a procedure not dissimilar to that used for fusing hydrogen atoms in Zeta and Sceptre III.

The Future

Within the last few years we have entered a new era in electrical technology. Increasing knowledge of the structure of matter and of the properties and behaviour of the ultimate particles of which matter is composed have led to major advances in the production of energy as shown by our nuclear power station projects, on the one hand, and to such developments as semi-conductor devices on the other. The use of semi-conductors enables extremely high-speed switching of electrical currents to take place and as a matter of fact this concluding section of my talk is taking place over what is called a talking-path-diode, or for those more technically minded, a p.n.p.n. diode. With these and other electronic devices entirely new types of telephone switching systems have been developed. Many devices of this nature have already been produced with the object of developing all-electronic telephone exchange equipment. Great progress has been made, and within a year or two this country will have in operation a complete electronic public telephone exchange as a result of combined research and development effort of the major telephone companies and the British Post Office.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

HIGHER TENSILE STEEL CHAIN SLINGS HIGHER TENSILE STEEL HOOKS

No. 2902 : 1957 and No. 2903 : 1957. Price 10s each. The products specified in these publications have higher minimum tensile strengths than those covered in the "sister" specifications—B.S. 781 "wrought iron chain slings" and B.S. 482 "wrought iron and mild steel hooks."

B.S. 2902 deals with slings of short link chain, in a nominal size range of from $\frac{1}{4}$in to $1\frac{1}{2}$in. Requirements are specified for single, two-leg, three-leg and four-leg reevable and non-reevable collar slings and for their components. Among much useful information provided are the following :—a set of requirements for the testing machine, details of proof testing and proof loads, a form of certificate of test and examination, recommendations for safe working loads and a table of maximum permissible working loads for alternative non-standard rings.

B.S. 2903 deals with seven types of hand-forged or drop-forged hooks of trapezoidal and circular cross section. Three of the types are shank hooks, and four are eye hooks. Among the requirements in the specification proper are those for proof testing and inspection. As in B.S. 2902, a form of certificate of test and examination is provided.

Both standards contain requirements for the "quality marking" of the products. Notes are provided which give the size of mark to be used for the different safe working loads (for hooks) and the diameters of the rings or links (for slings). In the chain slings standard the section following the Foreword, and preceding the specification, contains three pages of "Descriptive notes," followed by "Notes on design" (giving simple formulæ for calculating proof loads for links and rings), and a table of safe working loads for two-leg slings, with instructions on its use to find the working loads for three-leg and four-leg slings. "Notes on design" are also a feature of the standard for higher tensile steel hooks. The contents have been arranged for speedy and easy reference. One section of B.S. 2902, for example, deals with the components of the various types of sling by the "two-page spread" method of presentation—i.e. by relating full page illustrations to facing pages of tabulated data.

MANHOLE AND INSPECTION OPENINGS FOR CHEMICAL PLANT

No. 470 : 1957. Price 3s. The Factories Act, 1937, incorporated the requirements for manhole openings specified in the first edition of B.S.470, which was issued 25 years ago. At the request of the Joint Standardisation Committee of the British Chemical Plant Manufacturers' Association and the Association of British Chemical Manufacturers, the standard has now been revised to deal with manhole openings, hand holes and inspection holes for chemical plant and for mobile tanks for chemicals.

The dimensions for manholes are grouped under the three specified shapes : oval, rectangular and circular. Those for hand and inspection holes are grouped under two shapes : oval and circular. The standard includes an appendix which lists standards in which the number and positions of manholes &c. are laid down.

LETTERS AND LITERATURE

Letters to the Editor

We do not hold ourselves responsible for the opinions of our correspondents)

RAILWAYS INTO ROADWAYS

SIR,—The letter you published in your issue of February 21, from Mr. E. C. Gordon England of the Railway Conversion League, supporting Brigadier Lloyd's scheme for turning railways into roads, contains points that will appear sound to the superficial reader, but how much analytical examination will they stand ? For example, his suggestion that Brigadier Lloyd, in doing his best to make this country support his pet and in many ways nebulous ideas, is making a great gift to the nation, is extremely foolish and it becomes more so when he decries your editorial suggestion that the Brigadier should work out more details to prove the practicability of his scheme, advocating instead that this should be a matter for "indolent and complacent authority to undertake as a duty to the tax-payer."

There are a lot of guess-work figures masquerading as "sound estimates" used by whole-hogging road enthusiasts. Mr. England, for example, states that "... traffic delays are costing the British citizen more than the whole of the traffic receipts from the railways ! This loss is variously estimated as between £500 and £1000 million a year." What rubbish ! Of what urgency is a large amount of the traffic, some of it commercial as well as private, which is cluttering up our roads ? To give an example, I recently observed a large vehicle, of pantechnicon dimensions, causing a big traffic jam in Villiers Street, W.C.2., which is a narrow but much used street running alongside Charing Cross southern main line station. Now this giant vehicle was labelled with the name and address of a sweet manufacturer of a north western town. It was quite absurd that it should be causing a traffic jam in Villiers Street after having no doubt caused a good deal of delay and traffic congestion on more than 200 miles of main road in carrying its vital cargo of sweets to London, and no doubt it also could not travel as fast as it might have done because of much other traffic some of it of like nature. The time lost by such traffic in a journey to London and in getting jammed in narrow streets in London, for which such vehicles are in any case unfitted, is no doubt included in the figures quoted by Mr. Gordon England as purporting to show the cost falling upon the British citizen for not having borne the tremendous burden, not only directly but in damage to the National Economy, of providing all the road space, including the conversion of the railways, demanded by the road enthusiasts.

People who recognise that the most efficient transport is obtained by making the proper use of railways and that every form of transport has its appropriate place, appear to be somewhat scathingly regarded by those who cannot see themselves as a much worse brand of enthusiasts as "railway enthusiasts." The trouble about the "road enthusiast" is that in complete contrast he is an extremist and sees no value in any other form of transport than that of roads. Hence the owner of any motor vehicle in this over-crowded country must be provided with roads that will enable him to get wherever he may wish, irrespective of necessity, at high average speed, and irrespective also of what this must cost every citizen. The burden of providing such facilities for every Tom, Dick and Harry who owns a motor vehicle and for the increasing number who are going to do so in the future, would in any case be ruinous. The road enthusiast, however, stops at nothing and thus those who prefer to travel by rail must be made to travel by road whether they dislike it or not. What this Railway Conversion League obviously seeks to impose is a complete transport dictatorship.

The root cause of road congestion and many other troubles that beset us is, of course, that we are seriously over-populated, which is so little recognised that even under such conditions we constantly import more people.

The one aspect, above all others, that makes the proposal so foolish is that conversion of our railways into roads would make all our transport dependent upon overseas oil, mainly from remote sources not under our national control. The world's store of oil is furthermore exhaustible and it is being used up in an increasingly profligate manner which the road enthusiasts obviously regard as the height of wisdom. That the policy of railway electrification, in order to make use of the new sources of energy and to make our transport less dependent upon imported oil, is the right one should be obvious to all sensible people. How soon some minds forget the lessons of the last war and the Suez Canal trouble.

Consideration of the matter from this fuel aspect is alone sufficient to condemn the proposals for converting railways into roadways as utterly absurd and it is surprising that so many responsible papers and journals have given the matter so much publicity.

R. D. REYNOLDS,
A.M.I.E.E., M.Inst.F.

Twickenham,
Middlesex,
March 4, 1958.

SIR,—The only benefit likely to arise from fantastic proposals to convert the railways into roads is that some attention may be focused on the privileges allowed to road transport in this country.

For well over a century there has been an increasing tendency to force economic activities to bear in financial cost what they might otherwise pass on to the community in social cost ; but so far the one exception to this trend has been road transport. Everything which has happened here has fully justified the fears of those nineteenth century legislators who sought to hamper the utilisation of mechanically propelled vehicles on our roads. The annual toll in deaths and maimings constitutes a concealed subsidy to this form of moving goods and people from one place to another for which it would be difficult to find a parallel in any other economic activity.

It is not easy to ascribe a cause for this situation. One reason may lie in the fact that its continued toleration responds to a widely diversified vested interest. We all have a vested interest in having, either for pleasure or for profit, our own road vehicles in the operation of which we seek the minimum state regulation, regardless of the subsidy in life forfeited which this forces others to pay. But there are other less immediately discernible vested interests involved. The production of cars and lorries is by flow production where maximum output is a condition of low cost ; and when the saturation of the roads threatens to build up operating costs, so making the alleged economics of road transport less conspicuous, it would no doubt be a comfort to these manufacturers if they secured extended openings for their wares by the conversion of railways into roads.

Now the very nature of road transport precludes its operation to the same standards of safety as the railways ; but if the competitive efficiency of British industry is such that it cannot operate without subsidised transport, then let that subsidy be a money subsidy paid to that form of transport which can carry without killing, in preference to that subsidy in life paid by we know not whom tomorrow without which the other system cannot operate. To this end it is suggested that the British Transport Commission should be relieved of its obligation to meet the interest burden on British Transport Stock, provided the advantages are passed to users in reduced charges.

A further objection to these curious proposals to substitute road for rail transport lies in the fact that it would enlarge and perpetuate the dependence of our transport on precarious foreign oil supplies ; whereas the railways, fully electrified, open a possibility of utilising the promised cheap source of power in nuclear fission.

Finally, the revival of the railways as the major form of transport would have a further beneficial effect in contracting the size of our motor manufacturing industry. This is an industry with the features of imperfect competition ; of which the two most wasteful practices are artificial product differentiation and artificial product innovation ; the latter being the more serious. They result in the employment of high quality technologists, technicians, stylists, draughtsmen, planners, and all those associated with retooling, in a constant quest for innovation and change to find some new thing to put before the public

every three or four years or sooner. It is very questionable whether we can afford this continued misuse of scarce resources which might better be deployed in those science based industries where our advantage is the greatest.

J. E. CULE

Cardiff,
March 4, 1958.

Book Reviews

Fundamental Principles of Transistors. By J. EVANS. Heywood and Co., Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 45s.

POSSIBLY one of the most exciting features of the transistor is that it is likely to be a far more reliable amplifying device than its thermionic valve counterpart. This will almost certainly bring about an extensive application of electronic techniques to the industrial field, where a very high premium is usually placed on reliability. It is hardly surprising, therefore, that the electronic components industry is deploying increasing amounts of its resources towards developing and manufacturing the transistor. However, when a new subject develops at such a rapid pace, many problems must be faced, not the least of which is that of making sure that the scientists and technologists can get their subject into perspective. Everywhere, they are surrounded by what appears to be an avalanche of specialised technical papers dealing with narrow aspects of the subject. It is to help these people that Dr. Evans has written his book. Broadly, the book provides an introduction to the transistor, its basic physics, the materials that are needed to make it, and the various forms it can take. How it is used in electronic circuits is not discussed.

The theories of semi-conductor physics, which underlie the transistor venture are dealt with in reasonably simple terms. After answering the question of why single crystal material is necessary, Dr. Evans goes on to consider various aspects of electronic conduction in semiconductors. By then the reader is sufficiently acquainted with the concept of the " positive hole " to be able to understand the difference between minority and majority charge carriers and how the former can move and live. There follows a chapter describing how some of the physical characteristics of semi-conductors can be measured.

Possibly the main " break-through " in the development of the transistor was Shockley's appreciation of the mechanism by which rectification is obtained at a junction between p- and n-type semi-conductors. This p–n junction is discussed in some detail. This is as it should be, because once its principles are grasped the jump to the junction transistor is easy. Indeed, so easy is it that Dr. Evans is able to devote almost the whole of his chapter on the junction transistor to such detailed aspects as the way in which its gain varies with the operating point, and the factors that limit the maximum voltages that can be used. In order to keep the record complete it is probably as well that there is a chapter on the point-contact transistor, even though this device, the first of the transistor family, is of little practical significance these days. Of much greater interest is the chapter on special types of transistors, a chapter that manages to be remarkably up to date.

The book also contains a description of how germanium transistors are made, from the purification of the germanium itself to the carrying out of measurements on the final transistor in order to make sure that it will work satisfactorily. Germanium transistors form the main background to the book. Nothing is lost by this and one trusts that those who are more interested in silicon transistors will find the situation tolerably redressed in the last chapter.

In the arts, books and their authors provide mutual reflections of each other. In physical science and in engineering this is not often the case, possibly because the authors see their task more as one of recording facts than of contributing to literature ; in the majority of such works each chapter is almost an entity on its own. How refreshing to find that Dr. Evans has striven to keep away from this tradition by writing a book that is intended to be read as a whole and not as a series of parts. As a result one can sense the author's keen feeling for his subject and his liveliness as a teacher.

We are sure that this book, which combines clarity of presentation with reasonable balance of subject matter, will be widely read by newcomers to the transistor field. Circuit engineers coming face to face with the transistor and wishing to make a complete conquest, may also find it a rewarding book to read. Readers will find that references to further reading are well presented ; they do not seek to be all-embracing but, rather, to guide the reader into the more worthwhile channels. The word "fundamental" in the title of a book sometimes conjures up visions of extreme rigour, but readers need have no fears about Dr. Evans' book ; " fundamental " in this case means " an introduction to."

Twilight of the Railways : What Roads They'll Make. By BRIGADIER T. I. LLOYD. Forster Groom and Co., Ltd., 23, Craven Street, London, W.C.2. Price 5s.

THE author's proposal to convert the British railway system into a " reserved roadway system " will be familiar to readers of this journal, since it has quite recently been the subject of a " Leader " and subsequently of correspondence, in these columns. In this book the proposals are explained, but not in such technicality as they were in Brigadier Lloyd's paper to the Institution of Civil Engineers. In fact, the book is intended for the general reader, and is written accordingly, in a lively and persuasive style. But we think that the style of presentation will not be noticed so much by the reader, who will be intent on the proposals themselves. These we have already discussed and our opinions need not be repeated here.

Books Received

Mechanical Vibrations. By A. H. Church. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 54s.

Ideas, Inventions and Patents. By R. A. Buckles. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 48s.

Automation in Practice. By S. E. Russinoff. The Technical Press, Ltd., 1, Justice Walk, Chelsea, London, S.W.3. Price 55s.

Drainage Pipework in Dwellings : Hydraulic Design and Performance. By A. F. E. Wise. H.M. Stationery Office. Price 10s. 6d.

The Channel Tunnel. By H. Slater and C. Barnett, Allan Wingate (Publishers), Ltd., 12, Beauchamp Place, London, S.W.3. Price 21s.

Semiconductor Thermoelements and Thermoelectric Cooling. By A. F. Ioffe. Infosearch, 16, Ladbroke Gardens, London, W.11. Price 42s.

Electronic Measuring Instruments. Second Edition. By E. M. W. Banner. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 56s.

The Sources of Invention. By J. Jewes, D. Sawers and R. Stillerman. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 31s. 6d.

Technical Reports

Definition and Significance of the Flow Coefficient in Accelerated Flow, with Special Reference to Metering Devices. By T. H. Redding, M.Sc., F.Inst.P., A.M.I. Mech.E., A.F.R.Ae.S. B.S.I.R.A. Research Report M 30. British Scientific Instrument Research Association, Chislehurst, Kent. Price 5s. 6d.—Owing to the absence of an adequate theoretical treatment of fluid flow through enclosed channels of non-uniform section and, in particular, through constrictive devices, only in a limited number of cases is it possible to derive an expression that permits the accurate evaluation of the flow-rate in terms of the pressure drop over a specified length of channel. Therefore the conventional method of deducing a flow-rate from the pressure drop across a metering orifice or nozzle involves the introduction of a correction factor, generally known as the " discharge coefficient," which serves to effect agreement between theory and practice.

The objection to this approach is that it can lead to serious misconceptions as to the true significance of the " discharge coefficient," particularly where the teaching of enclosed-channel phenomena is concerned. It is the author's experience that students and others coming fresh to the subject are troubled by the artificiality of the " correction factor " method, and therefore fail to appreciate the relative functions of the theoretical and empirical approaches in the derivation of working formulæ for design purposes.

The immediate stimulus for the present text was therefore the obvious need, of both flow specialists and students, for a systematic treatment of enclosed-channel flow problems, by means of which it is possible to establish non-dimensional flow-coefficients that will facilitate the presentation and interpretation of experimental data for subsequent use in the design of flow metering devices.

This booklet is a reprint of a paper that was originally published in the October, 1957, issue of the *Journal of Electronics and Control.*

Some Proposals Regarding the Definitions of Terms Relating to Various Flow Régimes of a Gas. C. H. E. Warren and A. D. Young. A.R.C. Current Paper No. 368. H.M. Stationery Office. Price 1s. 6d.—In recent years there has been a rapid expansion of the ranges of speed and altitude that are of practical interest to aircraft and missile designers. In consequence, several new terms have been introduced to describe the new flow régimes that require to be considered, and, at the same time, the meanings of some of the older terms have undergone a measure of modification. The meanings attached to these terms by different workers have not always been consistent, differences have sometimes arisen from the differences of outlook between theoretical and experimental workers or between those concerned primarily with the motion of a fluid and those concerned primarily with the forces on a body in the fluid. To avoid the confusion that may readily arise if such differences become too well established it was felt desirable at this stage to attempt the formulation of unambiguous definitions of the more important terms in current use.

A Method for Calculating the Pressure Distribution Over Jet-Flapped Wings. By D. Küchemann. Reports and Memoranda No. 3036. H.M. Stationery Office. Price 7s. 6d.—The incompressible flow past an aerofoil with a thin jet emerging from its lower surface somewhere near the trailing edge is considered. Based on unpublished work of Gates, Maskell and Spence, a simple method is described for calculating the pressure distribution over wings of non-zero thickness. The effects of finite aspect ratio and of camber are included, and the method can be used for design purposes. The possible effects of sweep are briefly discussed. It is pointed out that a saddleback chordwise loading is typical for aerofoils with jets and that this is the basic reason for many of the aerodynamic advantages of the jet-flap system.

Catalogues and Brochures

F. E. CALLOW (ENGINEERS), Ltd., Birchill Road, Kirkby Trading Estate, Liverpool. Leaflets giving details of backbladed fans for dust extraction, air conveying, and a vertical batch mixer, suitable for dry materials.

FRY'S DIECASTINGS, Ltd., Midland Works, Brierley Hill Road, Wordsley, Nr. Stourbridge.—Booklet entitled " Diecastings—Your Questions Answered." It is directed to answer any questions that customers might have regarding diecastings.

AUDLEY ENGINEERING COMPANY, Ltd., Newport, Shropshire.—Illustrated publications entitled " Audco Valves—Power Operation and Remote Control," and " Electrically Operated Audco Valves."

DAVEY, PAXMAN AND CO., Ltd., Standard Ironworks, Colchester.—A pictorial review of some of the interesting locomotives with which the company has been associated over the last twenty-five years.

ROBERTSON THAIN, Ltd., Ellesmere Port, Wirral, Cheshire.—Publication No. LR103, describing a method developed of applying insulation to the underside of protected metal roofs and walls without disturbing existing cladding.

Q.V.F., Ltd., Fenton, Staffs.—Brochure entitled " The Climbing Film Evaporator," illustrating a unit with a single 1in bore Calandria tube, suitable for operation either at atmospheric pressure or under vacuum as a single-pass or recirculation unit.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Metals Division, P.O. Box 216, Birmingham, 6.—Leaflet describing some of the non-ferrous rolled sections manufactured by the company.

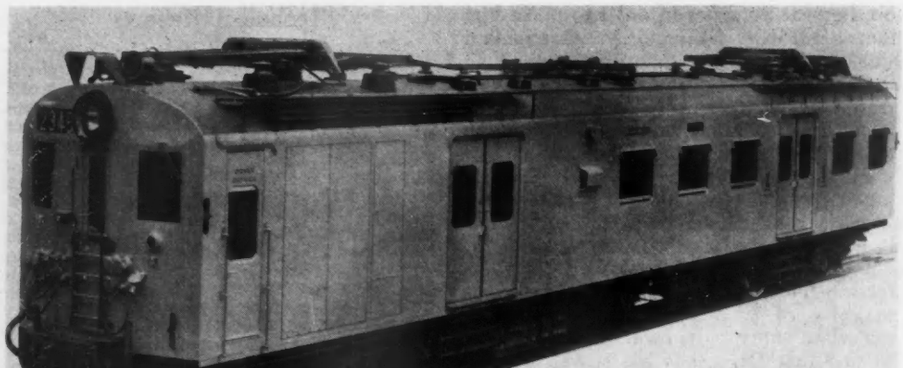


Fig. 1—Motor coach with baggage van and seating accommodation for forty passengers. This coach has a tare weight of 61 tons 2 cwt

Electric Trains for South African Railways

Particulars have been received from the Metropolitan-Cammell Carriage and Wagon Company, Ltd., of the electric coaching stock to the value of over £7,000,000 the firm is building for the South African Railways. The first vehicles supplied to this order have successfully completed running tests and were placed in regular service in February last. These particulars include notes on the methods adopted for stress analysis and calculations of the body shells which carry structural loads.

THE main contractor for the design and manufacture of 349 electric coaches for the 3ft 6in gauge Reef System of the South African Railways is the Metropolitan-Cammell Carriage and Wagon Company, Ltd., of Saltley, Birmingham, and deliveries of the new vehicles were begun in the last few months of 1957. The order included 105 motor coaches and 244 trailer coaches, of which seventy motor and 123 trailer coaches are being built at the main contractor's works, and the remainder by the Birmingham Carriage and Wagon Company, Ltd. The main electrical equipment for all the stock is being supplied by the Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester. Typical vehicles of this new stock are illustrated on this page. Of the 105 motor coaches ordered, sixty have upper-class accommodation, ten have a guard's and baggage compartment with upper-class accommodation, and thirty-five have a guard's and baggage compartment with third-class accommodation. Of the 244 trailer coaches 211 are for upper-class and thirty-three for third-class passengers.

The trains are designed to run from a 3000V d.c. supply from overhead wires and can be driven from a cab at either end of a train. A typical eight-coach train consists of six trailer coaches with a motor coach at each end, the main dimensions of the vehicles being as follows :—

Length over body end panels	60ft 3½in
Width over body panels	9ft 3in
Centres of bogies (motor coaches)...	41ft
Bogie wheelbase (motor coaches)	9ft
Centres of bogies (trailer coaches)	44ft 6in
Bogie wheelbase (trailer coaches)	6ft 9in
Track gauge	3ft 6in

Body Construction

The general construction of the cars is based on the integral tubular anti-telescopic principle, in which the whole body shell is considered as a rectangular tube with rounded corners, stiffened at intervals in its length by lateral rings formed by the cross bars, body-side pillars and carlines. These lateral rings are maintained in position by the continuous longitudinal stiffening members, such as cantrails, body-side rails, purlins and solebars. All these members are welded at the joints with other members and also to the outer skin, the whole forming the self-supporting and load-carrying body shell. A cross section of the body shell of a coach is shown in Fig. 4. The designs were prepared to give lightness to the trailer cars and, commensurate with adequate strength, to carry the extremely heavy peak loads specified, together with 200 tons end loading. It is interesting to note that a trailer coach shell, such as that shown in Fig. 3, and weighing just under 10 tons, will support a loading of over 33 tons.

The underframes of the trailer coaches are built up from folded or drawn section for the solebars and cross bars with a strong longitudinal troughing below the cross bars which is stitch-welded to the solebars. This troughing is 16 s.w.g. material, whilst the solebars and cross bars are $\frac{3}{16}$in and $\frac{1}{8}$in thick, respectively. The cross bars run continuously from solebar to solebar and there are no conventional longitudinal members. A cross beam has been added between the bolster and the headstock to deal with the buffing loads from the end longitude and to distribute these loads between solebar and bolster and thence to the troughing which provides the main member dealing with buffing loads. The channel section headstocks, made from $\frac{3}{16}$in rolled plate, have a large over-rider casting secured in the centre to prevent the couplers from separating vertically in the event of a collision and thus minimising the risk of telescoping.

The body sides are built up from drawn section main framing members, to which the 14 s.w.g. panels are spot-welded. The body pillars, cantrail and crib rails are of 12 s.w.g. material, whilst longitudinal rails are in 14 s.w.g. material. All framing members, both vertical and horizontal, are continuous and the body pillars are notched as required to pass the longitudinal rails. The panels, which are pressed for window openings and doorways, are automatically seam-welded before being spot-welded to the framing. Shallow "top hat" sections are used for the horizontal rails and modified channels for the pillars.

The principle of the roof construction is similar to the body side ; the carlines, which are individual pressings from cantrail to cantrail, are notched to allow the V-section purlins to be continuous from one end of the roof to the other. The frame members are welded to each other and stitch-welded to the roof sheets. The end framing is somewhat more rigidly constructed because of the possibility of collisions, although folded and drawn sections are again used in conjunction with 14 s.w.g. panels.

This structural description covers the trailer coaches, the motor coaches being very similar above the solebars, although below this level the underframe has been strengthened to carry the heavy electrical equipment.

Calculations

A careful stress analysis was conducted at every stage of the design of the new vehicles and we have received from the makers a brief description of the methods employed. The complete determination of stress and deflection characteristics of any coach structure involves a number of complex problems and in this particular contract such calculations were more than ever necessary in view of the exacting requirements, relating to weights and strength, imposed by the S.A.R.

Most important amongst various loading

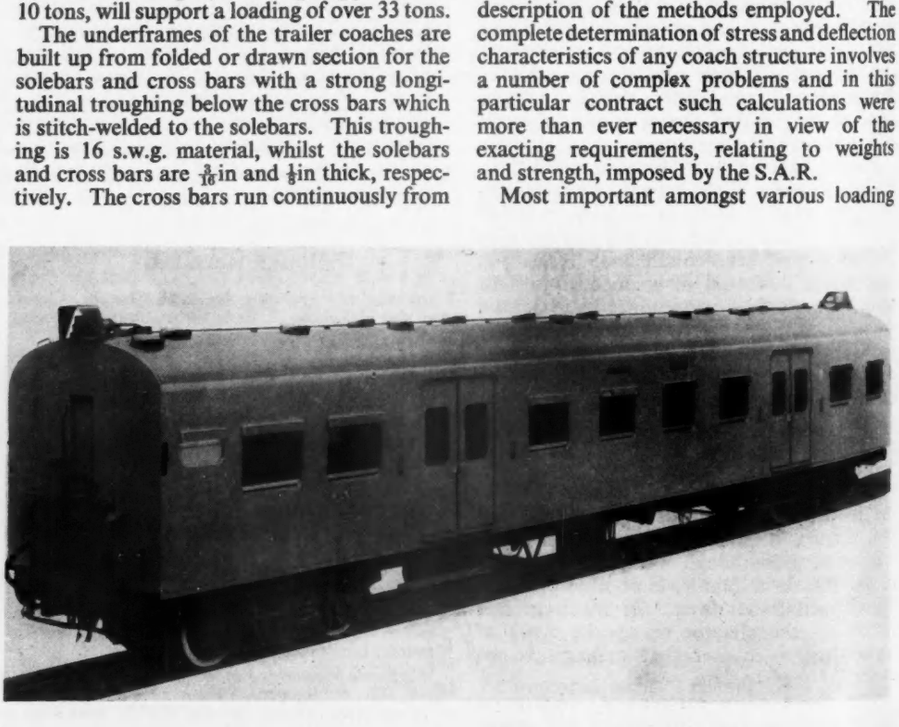


Fig. 2—Typical trailer coach to seat sixty-two first-class passengers. This coach has a tare weight of 30 tons 15 cwt

conditions considered were the following :

(*a*) Vertically applied loads due to structure, equipment and passenger weights, representing in one case a load of 33 tons.

(*b*) Horizontal loading due to traction, braking and buffing forces. In this load category all coaches had to be proved capable of withstanding a minimum of 200 tons applied at the centre coupling without damage. At end loadings, above this figure, it had to be arranged that damage should first occur in the areas between bolster and headstock before any damage occurred between bolsters.

In the calculations of the basic structure all interior finish and furnishings were neglected, and the steel shell represented as a Vierendeel or rectangular framed truss simply supported at two points coinciding with the centre pivots.

Fig. 3—Interior of a trailer car shell

It has been proved by many tests undertaken by Metro-Cammell in the past that in the horizontal plane the unity of the main structure is impaired by the opening required for doors and windows, and that deflections under vertical loads take place about two horizontal neutral axes. One of these is above windows and doors within the group of members formed by the cantrails, purlins, upper body side sheets and roof sheets ; the other is situated within the lower structure below doors and windows. Vertical connections between these two main groups are formed by the pillar structures and quarter panels whose neutral axes complete the representation of the structure as a series of rectangular frames, which can be solved analytically.

As a first step, one member in each rectangular frame was assumed to be severed at its mid-point and sufficient forces introduced at that point to represent completely the function of the continuous member (see Fig. 5). This involved three forces, X_1, X_2 and X_3, capable of simulating any condition of bending, shear or direct force in the member.

The external loading was then applied to the structure and the resulting deflections at each cut or break were equated to the component deflections induced at the same cut by unit loads applied in the position and direction of the unknown X forces. Thus, a series of simultaneous equations was evolved, the unknown X forces representing the magnitude of forces introduced into the primary structure. Thus, it may be stated :

$$Xa \,.\, \delta a \,.\, a + Xb \,.\, \delta a \,.\, b + Xc \,.\, \delta a \,.\, c + \ldots\ldots = -\delta a \,.\, 0 \quad (1)$$

where

$\delta a \,.\, 0$ is deflection in direction of Xa at a point where Xa acts when all external loads are applied to the structure.

$\delta a \,.\, a$ is deflection in direction of Xa at a point where Xa acts when unit load is applied at Xa.

$\delta a \,.\, b$ is deflection in direction of Xa at a point where Xa acts when unit load is applied at Xb. And so on.

The values of δ were calculated from the following standard equation of work :

$$\delta a \,.\, b = \Sigma \left[\int_0^l Ma \,.\, Mb \,.\, \frac{ds}{EI} + \int_0^l Pa \,.\, Pb \frac{ds}{EA} + \int_0^l Qa \,.\, Qb \,.\, \frac{ds}{GA} \right] \quad . \quad . \quad . \quad (2)$$

Where Ma, Pa and Qa are bending moment, direct load and shear force, respectively, in length ds of any member of the frame caused by the application of unit force in position of Xa ; and Mb, Pb and Qb are similar quantities due to the application of unit force in the position of Xb. The summation embraces all members affected by both Ma and Mb.

The above terms, involving deflection due to shear forces and direct forces, have a minor influence and they were eliminated.

Therefore,

$$\delta a \,.\, b = \Sigma \int_0^l Ma \,.\, Mb \,.\, \frac{ds}{EI} \quad . \quad . \quad (3)$$

It will thus be seen that three unknown forces resulted from each bay of the body side structure, involving a somewhat lengthy series of equations, and these were successfully solved by recourse to the Gauss tabular method, which was found well-suited to slide rule or calculating machine.

Having obtained the true values of all X forces, these were applied to their respective positions and the internal distribution of bending moments, shear forces and direct loads plotted. The calculation of stresses then became a straightforward matter, using standard formulæ.

Once the internal bending moment distribution was known it was also possible to calculate the deflection of any point quite simply by applying unit load in the direction and position at which the information was required. The bending moment induced by the unit load was then integrated with the moment due to the loading conditions being considered, and the following information was obtained.

$$\Delta = \Sigma \int_0^l Mu \,.\, M \frac{ds}{EI} \quad . \quad . \quad . \quad (4)$$

Where Mu is bending moment due to the application of unit load at point being considered.

M is bending moment in any member due to loading condition under consideration.

It is perhaps worth noting that the results obtained by using these methods proved a good guide to the behaviour of the first coach under actual strain gauge testing, when no weakness in the basic structure was found.

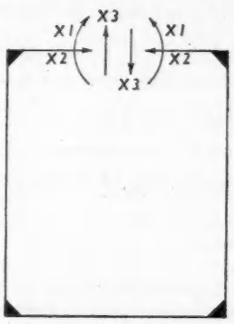


Fig. 5—Analytical representation of frame

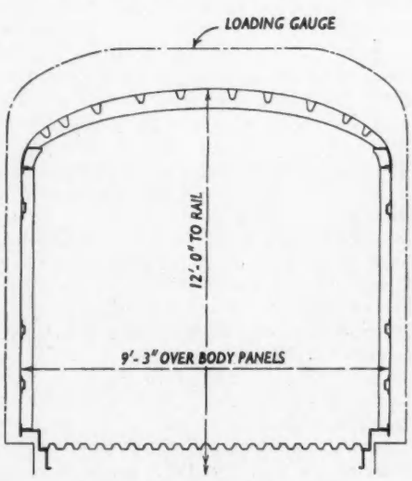


Fig. 4—Cross section of coach shell

As an indication of the results achieved by the design and calculations the following are the final weights obtained for these coaches :

	Tons	Cwts
* Trailer coach (complete)	30	9
* Motor coach (complete)	60	10
Trailer bogie (complete)	6	1
Motor bogie (complete with motor)	14	16

Bogies

Both the motor and the trailer bogies are of cast steel and of equalising beam construction, their structural design and springing being that of the General Steel Castings Corporation. The bogies have large diameter cast steel centre bearings with non-metallic wearing plates and sleeves. Due to the large centre bearings fitted, conventional side bearers are unnecessary, and are replaced by safety stops which have a nominal clearance of $\frac{1}{4}$in per side. Bogie springing is by nests of helical springs, damped by Houdaille

* These weights do not include vacuum brake cylinders which are supplied and fitted by the South African Railways.

shock absorbers. In the interests of comfortable riding, the springing has been designed to give maximum deflection under load compatible with the working clearances required between the bogie parts and the underframe. The radial movement of the bolster is controlled at its outer ends by bolster anchors, which flexibly locate it to the bogie side frame.

The bogies are equipped with orthodox equalised vacuum-operated clasp brakes operated from the underframes by the usual pull-rod linkage. All bogies are fitted with Skefko self-aligning roller bearing axleboxes. In the motor bogies both axles are motorised, the motors being axle-hung with their noses flexibly mounted on the bogie transoms.

Motor Coaches and Electrical Equipment

Approximately one-quarter of the total body portion of a motor coach length is occupied by electrical and equipment compartments, and access to these compartments can only be obtained by operation of a mechanical interlocking gear, which automatically lowers the pantographs and cuts off the power supply. The main high-tension and auxiliary high-tension equipment compartments are slightly pressurised to prevent the ingress of dust when travelling. The high-tension compartment houses, amongst other items, the main switch group frame which may be removed directly out of the compartment without being dismantled.

Two other compartments provide for the intake and filtering of a fresh air supply for cooling the traction motors, air being taken in at the sides of the roof from where it passes down into an air settling chamber. From this chamber the air travels through a bank of Vokes filters and into the air intake chamber proper. This compartment houses booster fans which can be operated by the driver to force-ventilate the traction motors when necessary. Air can also be taken from the settling chamber by the traction motors themselves for normal cooling.

Current is collected by two pantographs from an overhead wire which has an average potential of 2900V, varying on the normal working conditions between 2700V and 3200V. The electro-pneumatic control system employs both unit and drum switches, remotely controlled from the master controller in the driver's cab. Current for auxiliary control is obtained from a motor generator set on the underframe, the motor of which is driven from 3000V line supply, while the generator supplies current at 110V. In the event of failure of one auxiliary set, control supply can be obtained from the other motor coach in the train.

The four traction motors are connected electrically in pairs, permanently in series, so that each motor, while insulated for 3000V to earth, has only 1500V across its terminals. The pairs are operated in series or in parallel; one stage of field weakening is provided, for which two inductive shunts are used. Provision is made for the isolation of any pair of motors which may become defective without interference with the working of the remaining motors.

The other items of auxiliary equipment on the motor coach, including the exhauster, compressor and main resistance frames, are all mounted on the underframe.

Tissue Paper Mill at Bridgend

Consideration of the possibilities of the market for tissue papers caused the Wiggins Teape group to plan a mill to manufacture this class of paper. This mill was built on a site near Bridgend in South Wales and is operated by Bridgend Paper Mills, Ltd. To the three machines already in production there has been added a fourth in order to match production with expanding demands for tissue paper. Our illustration shows the mill buildings with the filter plant in a separate building to the left and the river in the background.

In recent years the uses of paper have become manifold and the chemist has played an important part in developing the wide variety of products manufactured by the industry. One group of these products consists of tissue papers and the possibility of manufacturing this class of paper was given consideration by the Wiggins Teape group nearly twenty years ago. However, it was not until after the war that market research confirmed earlier opinions upon the possibilities of tissue papers for hygienic, industrial, and packaging purposes, and indicated that the tendencies were for the demand to increase. These findings influenced the decision to build a tissue mill and plans were put in hand while a search was made for a site which met the essential requirements for a paper mill, including the availability of adequate supplies of soft water allied with good road and rail access and the proximity of a port having suitable facilities. Such a site was found at Llangynwyd which is a few miles to the north west of Bridgend in South Wales. The site selected was close to a main road and the railway, water was available from the nearby Llynfi River, while the supplies of imported wood pulp could be unloaded at Cardiff and Port Talbot. In addition to these facilities the site chosen was close to the Llynfi power station, so that the mill did not require a separate power plant since steam and electricity were available from the power station.

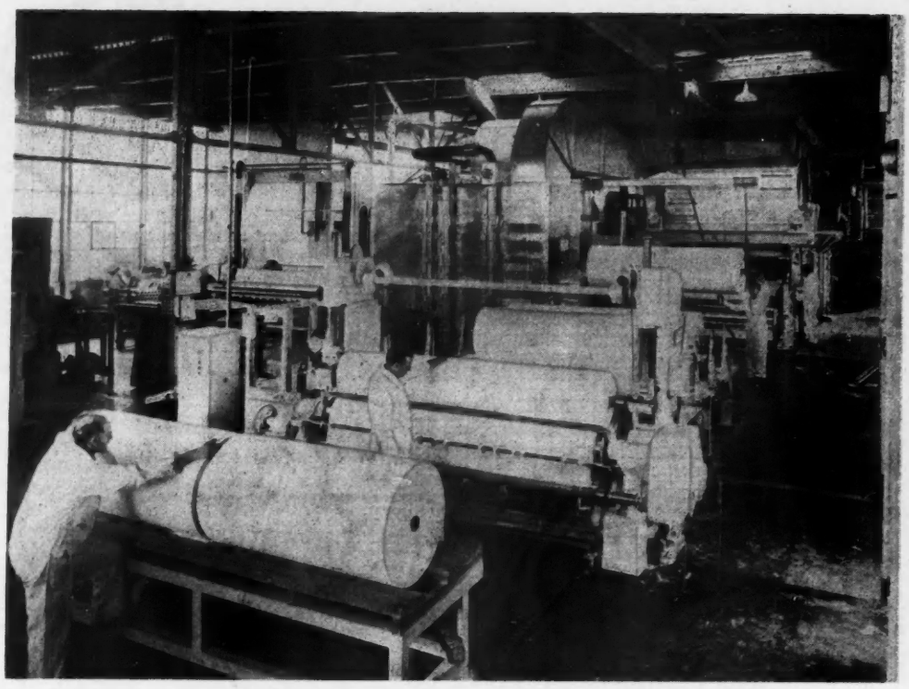
Production planning was based on the demand anticipated for various qualities of tissue and to cover this range it was decided to install three paper making machines and their associated equipment. These mills were not numbered in the customary way but were "christened" Jack, Jill and Baby. The first is a Fourdrinier machine designed to produce 125in unglazed tissues weighing from 19 to 30 grammes per square metre and semi-crepe papers of 20 to 40 grammes per square metre weight. Machine glazed tissues 125in wide by 17 to 30 grammes per square metre weight are produced by the second machine, while the third is much more versatile and produces a wide selection of special 100in dry crepe tissues ranging from 16 to 45 grammes per square metre in weight. By 1950 Bridgend Paper Mills, Ltd., was in production and operating continuously on a four-shift system for seven days per week, each shift worker averaging a 42-hour week.

In the succeeding years tissue paper found many more applications resulting in increased demand so that by 1957 production and sales had doubled the 1951 figure. Therefore it was decided to expand the capacity of the mill to meet further market expansion by adding a fourth mill. This decision was taken in November, 1956, and by January, 1958, the mill buildings had been partially reconstructed to house the new equipment, and the machine had been designed, built and installed, so that paper was being produced within a period of fourteen months. To-day the mill employs about 300 and the production exceeds 400 tons a week. Process water is drawn from the river Llynfi at a rate of 320 million gallons per annum or about 40,000 gallons per hour which is returned to the river after treatment in a Dorr Oliver "Clariflocculator." The power station provides 200 million lb of steam per year at a rate of 25,000 lb per hour while the present consumption of electricity is running at a rate of 2500 units per hour which totals about 20,000,000 units per year. Wood pulp is imported mainly from Scandinavia and Finland into Port Talbot and Cardiff and delivered to a pulp store, where the bales are handled by a 1¼-ton crane, which has a capacity of about 2,500 tons, an amount equivalent to between seven to eight weeks' supply. Some supplies in the near future will come from the new plant which has been built at Sudbrook and which will produce

"Gatecel" pulp from local hardwood trees and so effect a saving in imports.

Three 30,000 gallons per hour pumps are available to deliver water from the river to the filtration plant where the water is filtered by means of air scour, graded pebbles and anthracite. Another set of three 30,000 gallons per hour pumps forward the filtered water to the mill where it is delivered to the two Black Clawson hydrapulpers through measuring tanks. The "hydrapulpers" can take a 2000 lb charge and the amount of water used is governed by the weight of pulp and the consistency required which is generally about 6 per cent. The slushed pulp is passed to a battery of eight stock chests by two 2000 gallons per minute propeller pattern pumps. Each pair of chests has a common pump and the pulp is treated in Jordan refiners before passing to the headbox on the paper machines. All the pumps have been provided by Mather and Platt, Ltd.

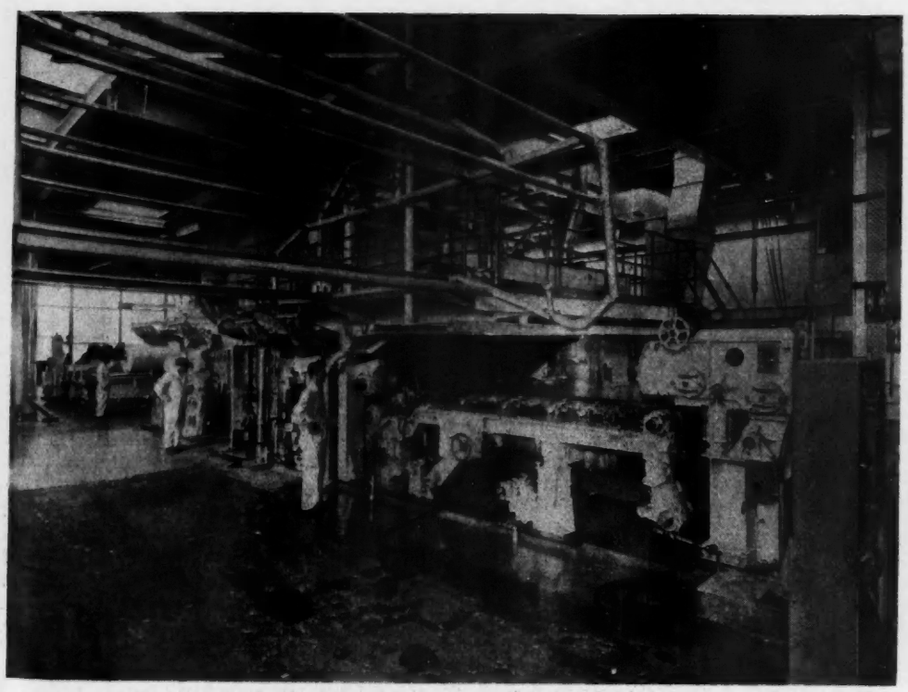
A Masson Midget refiner treats the stock at a rate of 20 tons per day for the new machine, which is named "David," and produces 100in dry crepe tissue at a maximum speed of 1500ft per minute. Our first illustration is of the tissue mill seen from the headbox end. The design of the machine was the work of the Bridgend Paper Mills staff with advice from the group technical and research department and it incorporates the experience gained over many years. Stock is cleaned by Dirtecs and Selectifier Screen equipment, supplied by Vickey's, Ltd., and Black Clawson International, Ltd., before admission to the pressurised headbox which has variable pressure formation and automatic controls. Stock is fed at the required volume on to the 108in wide endless woven wire screen stretched between rolls and passing over specially designed "Bakelite" scrapers instead of the conventional table rolls. The sheet is formed on the horizontal table formed by the moving screen through which the surplus water drains or is removed by a suction box. At the end of its horizontal travel the screen passes round a couch roll, to commence its return to the breast roll, and at this point the sheet is sufficiently coherent to be transferred to the underside of an endless lick-up felt which passes round the lick-up roll and is in contact with the wire at this point. The felt with the sheet underneath passes through a suction press consisting of two rolls over the lower one of which passes a felt, and a further amount of moisture is removed from the sheet at this point as it is squeezed between the two felts when passing through the nip of the press. With the sheet still adhering to it the upper felt passes over return rollers so that the sheet is now on top and then passes over a pressure roll, so that the sheet is brought into contact with and is transferred to a 10ft 6in diameter drying cylinder. This M.G. cylinder was provided by Thiry and Co. of Belgium and takes steam at 35 lb per square inch gauge. The sheet is in contact with the cylinder over an arc of approximately 300 deg. and is then creped off by an oscillating doctor blade to pass through two calender nips to a reel drum. In contact with the drum is a core shaft upon which the creped sheet is reeled up. A special device provides for the removal of a completed roll and the introduction of a new core shaft. A jet of air passed across the width of the paper breaks it and at the same time transfers the end to the new shaft so that the reeling operation is continuous. A crane picks up the full reel and transfers it to the reel-up, multiply rewinder and slitter, seen in our illustration. A high velocity hood, supplied by the Carrier Ross Engineering Company, Ltd., gives extra drying capacity and incorporates a Keith Blackman fan of 40,000 cubic feet per minute capacity.



Calender section of mill with reel-up, multiply rewinder and slitter

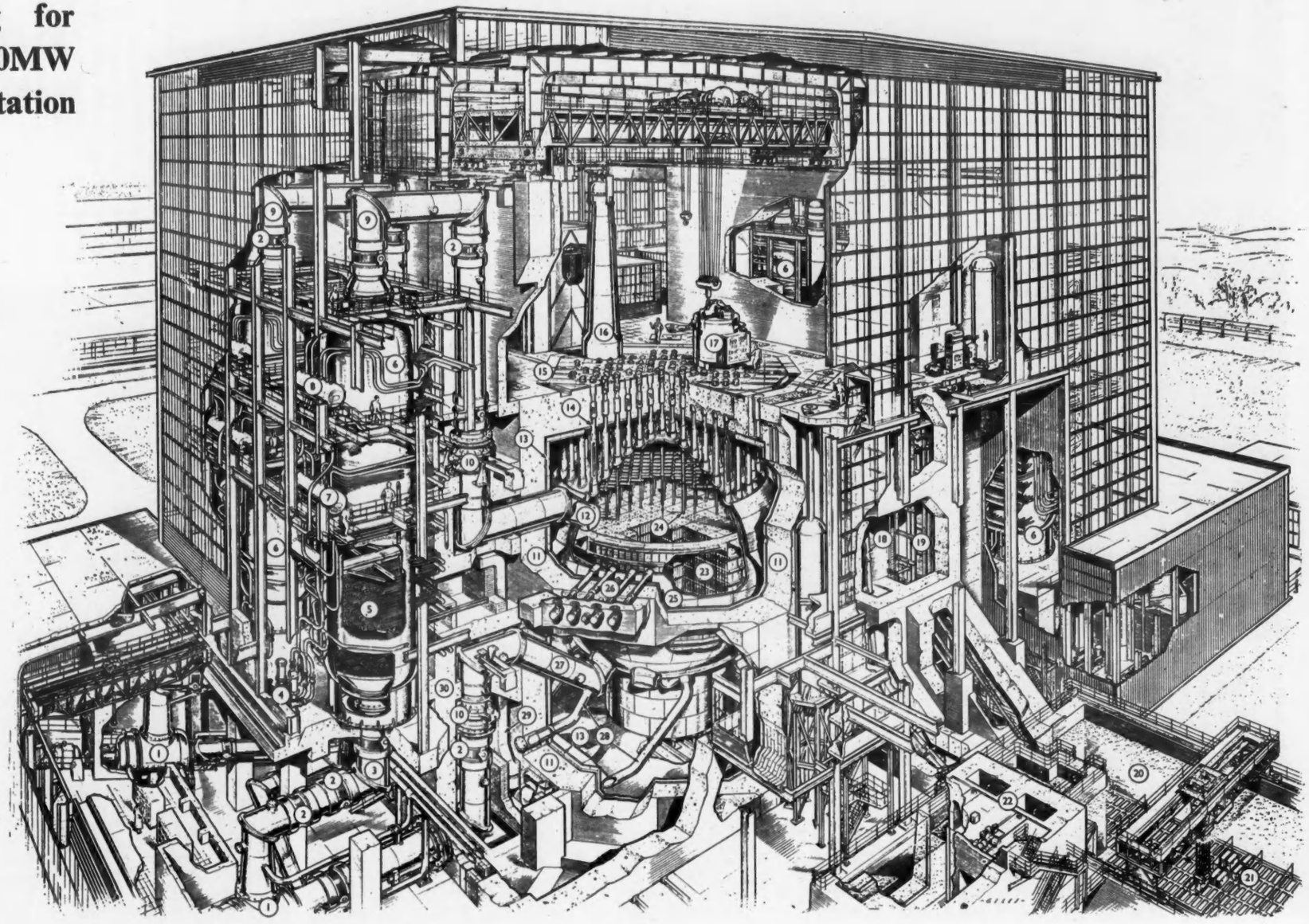
Four variable speed d.c. motors power the mill; one of 97 h.p. drives the M.G. cylinder while three motors each of 45 h.p. drive the wire screen, the felts and the drying and reeling group. In the latter group the motor drives through mechanical gearing and vee belts. Lancashire Dynamo Nevelin, Ltd., was responsible for the section electric drive and provided two sets of oil immersed transformers and grid-controlled mercury arc rectifiers, one set to supply the wet end motors and the other, the drying end motor. The "Varionic" drive control gear enables the speed of the two groups to be adjusted either independently or together in order to control the creping effect. Armature voltage of the drive motors is varied by control of the rectifier grids and there are no speed synchronising sets since the drive motors are specially designed to match speeds. However, there are facilities for trimming controls in the wet end of the mill to equalise the power supplied to each of the three motors in order to ensure that the felt is not torn. All the motors have a high overload capacity, up to 100 per cent.

Welded mild steel framework has been adopted instead of the more usual castings for the mill and it is of interest to note that the design provides for a short cantilevered wire section to facilitate wire-screen changing. The tubular former for carrying the wire screen can be seen to the left of the machine, in the second of our illustrations. To deal with the fibre which passes through the wire table there is installed a fully automatic sedimentation fibre recovery system which is of the company's own design.



Mill showing wire table and stock inlet

Reactor Building for Hinkley Point 500MW Nuclear Power Station



1—Coolant gas circulating blowers.
2—Hinged expansion bellows.
3—Coolant gas outlet from steam-raising unit.
4—Steam-raising-unit circulating pumps.
5—Stud tube elements.
6—Steam-raising units (six per reactor).
7—Low-pressure steam drum.
8—High-pressure steam drum.
9—Coolant gas inlet to steam-raising unit.
10—Coolant gas isolating valves.
11—Main biological shield.
12—Coolant gas outlet from reactor.
13—Thermal shield.
14—Charge tubes.
15—Charge floor.
16—Hole-preparation machine.
17—Charge and discharge machine.
18—Emergency discharge chute.
19—Spent fuel element skip hoist.
20—Cooling pond.
21—Storage skips and grid.
22—Skip loading bays.
23—Graphite moderator core.
24—Control rod.
25—Reactor pressure vessel.
26—Can failure detection standpipes.
27—Coolant gas inlet to reactor.
28—Debris-removal ducts.
29—Shield cooling air ducting.
30—Secondary biological shield.

SHORTER REPORTS

Standard Screw-Thread Practice

THE council of the British Electrical and Allied Manufacturers' Association (BEAMA) has issued a booklet* giving guidance to its member firms on standard screw-thread practice in British engineering, and on the use of Unified Screw Threads. In the belief that the views expressed in this booklet may be of interest outside BEAMA, we reproduce below abstracts from the text.

The BEAMA council and its standardisation committee have given considerable thought to standard screw-thread practice in British engineering and the use of unified screw threads, and this booklet explains why the council considers British Whitworth and British Association threads should continue to be used as the standard production practice of the industry.

(1) The Unified Screw Thread arose from discussions during the war between Government bodies of America, Britain and Canada, in connection with products for war purposes, and our industry co-operates with Government departments in developing the special equipment required by the Armed Forces. The suitability of their practice as a standard for the home and export markets of British industry is, however, an entirely different matter.

(2) For normal plant and products a standard interchangeable screw-thread practice is essential for economical production within the industry and for a continuance of goodwill and acceptance of its products in world markets.

(3) Our industry, as one of the largest exporting industries in the U.K., would welcome a world standard screw-thread system, but at the present time the International Standards Organization is unable to get agreement on one recommendation and it is considering recommendations for both an inch and a metric system. The Whitworth thread has not been put forward for consideration in the ISO and it is the Unified thread based on American National practice which is under consideration.

(4) If the ISO makes two recommendations no one can foretell which of the two is likely to possess the greater potentiality for practical adoption, not only in Britain's traditional markets, but also in the future markets of the world.

(5) The recent adoption of the Metric system by other countries in the Far East, coupled with European integration, may materially influence the demand for Metric screw threads and increase advocacy for their acceptance as the world standard.

(6) At present, the British Standard Whitworth thread system has as wide, if not wider, usage throughout the world than any other and there is no indication that it is now less generally acceptable overseas than in the past. On the other hand, there is indication that engineers abroad, where Whitworth and B.A. threads have long been supplied and accepted, are raising criticisms when they find that some items of equipment in a composite installation supplied by British manufacturers have a different thread.

(7) When the final recommendations of the ISO become available and an assessment can be made as to which of the two recommended standards is likely to be more generally acceptable than the present British standard, then will be the time for the British engineering industry to consider again the pros and cons of any change.

(8) If at that time a change appears necessary or desirable it must be planned in the interests of economy and minimum inconvenience, both to the British engineering industry and those it serves at home and abroad. Not to do so would cause untold inconvenience in the maintenance and extension of installed British equipment.

(9) Consideration of the problems as they may affect only one particular production or purchasing unit must inevitably lead to unilateral and conflicting decisions, the cumulative result of which will mean that the many advantages of a standard interchangeable screw-thread practice will no longer be available. What is essential is co-operative consideration of the problems as they will affect the future well-being of the industry as a whole.

For such reasons, the council is of unanimous opinion that any change-over to Unified Screw Threads at the present time, however partial, would be ill-timed, uneconomic and unwise. They feel that to justify any change to a recommended new standard, it must have greater potentiality for world-wide recognition and use in the coming century than the present British practice now enjoys.

Taking everything into account, the council considers that the only wise and common-sense course is a continuation of the BEAMA 1952 policy as stated below—a policy based on maintaining a standard production practice to the advantage of the majority of its customers at home and overseas.

Standard Practice.—The British electrical and allied industry should continue to use British Standard Whitworth and BA threads (including British Standard fine, pipe and conduit threads) in order to maintain its interchangeable practice for normal production, because these threads and systems are still the most widely used and accepted in the majority of its own world-wide markets and those of the British engineering industry.

Special Screw Threads.—For use in markets where Whitworth and British Association threads and systems have long been supplied and accepted, commercial plant and products should not be supplied with Metric, American National, Unified, or other special threads.

If a customer proposes to change from standard practice to a special thread, the request should continue to be treated like other requests which involve departure from standard practice and which interfere with efficient production, namely, by explaining to him the mutual advantages of accepting standard products and strongly advising him to accept British Whitworth and B.A. threads until acceptable world standards emerge.

For use in the few markets abroad where Whitworth and B.A. threads are not the generally accepted standard, commercial plant and products should continue to be supplied with Metric, or American National, or other special thread, only when such a thread is specified by the customer or when it is considered expedient for expanding export trade.

Service Equipment.—For special equipment supplied to meet the needs of the Armed Forces, the industry should continue to co-operate with Government departments by supplying Unified Screw Threads when firmly demanded.

* *Standard Screw-Thread Practice in British Engineering, and the Use of Unified Screw Threads.* Published by the British Electrical and Allied Manufacturers' Association, Incorporated, 36, Kingsway, London, W.C.2.

Review of Scottish Water Power

MR. A. A. FULTON, general manager of the North of Scotland Hydro-Electric Board, reviewed the progress made by the Board in its electrification programme for the Highlands, and gave his views on the way development would proceed in the future, in an address delivered at the Dundee Business Club on March 4. Only last week we printed figures of installed capacity and generation recorded in the Board's 1957 annual report, so that part of Mr. Fulton's address which covered much the same ground need not be repeated. He pointed out, however, that hydro-electric generation by the Board, from its formation up to the present, had been equivalent to a coal saving of 5,000,000 tons.

He went on to illustrate the basic principle of the 1943 Hydro-Electric Act, namely, that large schemes for the generation of electricity would operate at a profit and thus subsidise rural distribution. In 1957 the average cost to the Board of all the electricity sold had been 0·70d. per unit, he pointed out, including steam and diesel electricity; hydro-electricity had cost only 0·59d. per unit. The average cost of generation for the Central Electricity Authority, however, had been 0·86d. per unit, which gave the Board a margin of 0·16d. on every unit sold, to enable it to sell electricity at tariffs at least as favourable as applied over the rest of the country. In fact, tariffs were lower than in Southern England. The margin of 0·16d. amounted to about £1,000,000 annually, which was the extent to which generation subsidised distribution. Generation and distribution costs were quite different in the Board's area from elsewhere, there being only sixteen consumers per square mile compared with 162 in the rest of Scotland and 230 in Britain generally; the nearest comparable figure was 125 in South-west England.

Mr. Fulton went on to explain the importance of Highland water power in meeting peak loads, and how it would be especially beneficial in this respect in conjunction with nuclear generation. The total cost per kilowatt of nuclear stations, including the first charge of fuel, was much the same as that for a hydro-electric station, he said.

Future base load requirements in the Board's area might well be met by a nuclear station, Mr. Fulton continued, and the first steps had been taken to find a site for such a station with the object of having it in use in the late 'sixties. On the other hand, if the Loch Awe pumped storage scheme received Parliamentary approval, it would be in time to begin operating after the Hunterston nuclear station was commissioned in the early 1960s.

In answer to the criticism that none of the Scottish hydro-electric schemes had been built at the costs originally estimated, Mr. Fulton said that no substantial works of any sort carried out since the war over a period of years had been completed at the costs originally estimated. Inflation had been going on continuously; in 1944 labourers received 1s. 8d. an hour, and were now getting 4s. 0½d. per hour, whilst coal at the Board's power stations had increased from 40s. to 101s. 4d. per ton.

Hinkley Point Nuclear Power Station

THE illustration on the opposite page shows a sectional view of one of the two reactor buildings for the 500MW nuclear power station under construction at Hinkley Point, Somerset. This station is being built for the Central Electricity Generating Board by the English Electric—Babcock and Wilcox—Taylor Woodrow Atomic Power Group. A general description of the design of this station was published in our issue of September 20, 1957, page 415.

It may be recalled that each of the two gas-cooled, graphite-moderated reactors is contained in a 67ft diameter pressure vessel of steel 3in thick. The fuel is natural uranium in magnesium alloy cans, with refuelling from the top while the reactor is pressurised and on full power. For each reactor there are six Babcock dual-pressure boilers, each 90ft high and 21ft 6in in diameter, the total evaporation being 5,500,000 lb steam per hour. The gas coolant is circulated by six 3000 r.p.m. electrically driven, axial-flow circulators. Main electrical generation is by six English Electric hydrogen-cooled, three-cylinder turbo-alternators, each generating 93·5MW at 13·8kV, 0·85 power factor. Auxiliary power for the gas circulators and other services is generated by three 33MW variable-speed turbo-alternators.

Cover for Atomic Energy Risks

LONDON'S second international Atomic Energy Insurance Conference, held in the week ended Friday, February 28, resulted in widespread agreement by insurance men from fifteen countries of Europe on the broad approach to the insurance of risks arising out of the use of atomic energy reactor installations. The Conference was sponsored by the British Insurance (Atomic Energy) Committee. The Committee, set up in 1956, represents British insurance companies and Lloyd's underwriters. The atomic insurance pools of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Sweden, Switzerland, and Turkey were represented.

The object of this second Conference was to determine in the light of the experience of the past twelve months how the various insurance markets of Europe may work more closely together to provide insurances on a comprehensive basis for the many reactor installations now being built or contemplated, particularly on the Continent of Europe. The major questions discussed were as follows.

Pool Management Agreements.—The Conference exchanged views on the essential features of pool management agreements and there was a wide measure of accord on the form these should take. A pool management agreement is the instrument by which individual insurers bind themselves together to act as an insurance pool. It gives the pool legal power to operate on behalf of its members—to insure, co-insure, reinsure, pay claims, &c.

Types of Risks Which Should be Pooled.—It was decided that the material damage risks to be pooled should be the insurance of damage to property belonging to the policy holder, comprising damage to atomic installations, provided that insurance includes contamination by radioactivity and damage to any other property of the same policy holder due to contamination by radioactivity emanating from his atomic installation. It was also agreed that third party liability for damage to property and loss of life and injury to persons arising out of the use of atomic installations should be pooled. Broadly, atomic installations are defined as atomic reactors and atomic power stations and plant or any other premises or facilities concerned with the production of atomic energy or any process incidental thereto. It was unanimously agreed as a general principle that no atomic energy insurance pool would cover material damage to atomic reactors for nuclear risks only—in other words, each reactor must be covered comprehensively. A similar understanding was reached as regards the insurance of third party liabilities. A number of countries proposed separate pools for personal accident and workmen's compensation insurance, but the view prevailed that these two questions were domestic issues and should be settled accordingly.

Three of the items on the agenda are to be the subject of deliberations by a special committee. They are : (1) hazards, evaluations and surveys ; (2) bases of premium rating ; (3) policy cover to be offered. The Conference considered that agreement on these three questions was essential and a committee to consider them is to be convened in Paris in the second half of April. It comprises representatives of Belgium, France, Germany, Holland, Italy, Sweden, Switzerland and the United Kingdom.

Loss of Profits or Consequential Insurance.—The Conference endorsed the approach to the subject of the British insurance market. This is contained in a recommendation in the British Insurance Atomic Energy Committee's detailed report on atomic energy risks and their insurance published in June, 1957. It says : " The extent to which cover could be provided against loss of profits and consequential loss, following the shut-down of a reactor after an incident, would be a matter of market capacity. If the capacity had already been exhausted in the case of a large reactor installation, cover in this respect could not be provided. Where, however, the capacity had not been exhausted, insurers could consider the possibility of providing cover."

Channelling of Liability to Reactor Owners for Radiation Damage.—All the countries attending the Conference endorsed the principle that a single insurance policy be effected by the reactor owner/operator who should accept all responsibility for radiation liabilities for contractors and suppliers of parts, as well as for himself, and the owner/operator would undertake to indemnify the contractors and suppliers of the parts from any legal liability that they might have for radiation risks. This approach to the problem of channelling legal liability is that recommended in the British Insurance (Atomic Energy) Committee's detailed report referred to above. The object of such channelling is to ensure that any claim from a third party should be made simply and solely against the reactor owner or operator. In the United Kingdom, the Government has accepted that the problem should be tackled on these lines, and it proposes that the owner of a reactor shall be under an absolute liability at law and shall be required to insure to a sum of £5,000,000 or else show that he has liquid assets available to that amount.

Construction Risks and Products Liability.—In a number of countries, it will not be possible to channel liability to the reactor owner or operator at the outset. Where this situation pertains, the Conference decided that contractors working on the construction of atomic installations and suppliers of parts and materials should be offered individual policies to safeguard them against their legal liability, provided that the amount of cover required is within reasonable limits.

The Law and Atomic Energy Insurance.—The Conference unanimously resolved that special legislation must apply to legal liabilities arising from the use of reactors. This would involve the harmonisation as far as possible of existing law in the various countries. Legislation would deal with such matters as the channelling of liabilities, limits of liability and exceptions from absolute liability, i.e. act of God, and the periods within which claims against the operator must be notified. It was decided that these and related matters should continue to be dealt with by the Organisation for European Economic Co-operation and the Comité Européen des Assurances.

100MW Reheat Turbo-Generator at Ferrybridge

IN the accompanying illustration we show the first of three 100MW, 3000 r.p.m., turbo-generators to be installed by C. A. Parsons and Co., Ltd., in the Ferrybridge (Yorkshire) power station. This set, which is stated to be now running on load to C.E.G.B. requirements, has three cylinders and, with the exception of a two-row velocity wheel on the h.p. shaft, is fitted with reaction blading throughout. Initial steam conditions are 1500 lb per square inch at 975 deg. Fah., with reheating to 950 deg. Fah. between the h.p. and i.p. stages. Intercepting valves are fitted before the i.p. cylinder to provide a safeguard against the large quantity of steam stored in the reheater and connecting pipes flowing into the cylinder in the event of a sudden loss of load. Thrust bearings are located at the inlet ends of the h.p. and i.p. shafts, and a flexible coupling between these shafts absorbs axial expansion of the rotor assembly. A double-shell construction is used for the h.p. cylinder. Six similar machines are on order for the Aberthaw power station.

An interesting comparison can be made between these 100MW turbo-generators and the Parsons 120MW machines, thirteen of which are on order. The latter machines, with steam at the same initial pressure of 1500 lb per square inch, employ temperatures of 1000 deg. Fah. and reheat to 1000 deg. Fah. The h.p. shaft has been reversed, its inlet end being adjacent to the i.p. cylinder, and the flexible coupling between h.p. and i.p. shafts has been eliminated. All couplings are rigid, and the one thrust bearing is located at the inlet end of the h.p. turbine. These machines are destined for the C.E.G.B. power stations at Rugeley, Skelton Grange, Drakelow and Kincardine.

The first of three 100MW reheat turbo-generators to be installed at Ferrybridge

Mobile Air Compressors

WE are informed by the Hymatic Engineering Company, Ltd., Redditch, Worcestershire, that the firm's " Hydrovane " mobile compressor type " 98P100," hitherto available for export only, is now in full production and available on the home market. The main improvement over the " 60P100 " machine it now replaces is an increase of free air delivery to 72 cubic feet per minute, to operate a medium heavy concrete breaker continuously at full working pressure of 100 lb per square inch. It has an all-up weight of only 616 lb and can be wheeled across a site by one man, manœuvred over the roughest ground by two or, if necessary, carried bodily by four.

The modifications incorporated in the compressor include the replacement of the metal engine cowl and petrol tank by streamlined " Fibreglass " reinforced plastic units which are lighter and less liable to damage. An oil-wetted intake filter is fitted as a precleaner, in addition to the standard felt pad air filter, and a push-to-stop button replaces the ignition switch.

The air-cooled, oil-sealed rotary compressor

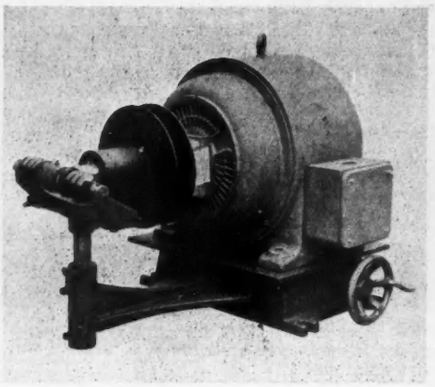
is designed to run for long periods with no servicing, other than routine oil changes and air intake filter cleaning. It is driven through a flexible coupling by a Volkswagen flat-four cylinder air-cooled petrol engine, the two units being bolted direct to a mounting flange. This assembly is carried on a simple frame of light alloy tubes with detachable carrying handles at each end. The undercarriage consists of two large diameter pneumatic-tyred wheels carried on an axle secured to the frame by quick-release clamps. With the undercarriage removed weight is reduced for carrying purposes to 584 lb, and if required the compressor can be operated thus.

Excess Fuel Selector

AN excess fuel device for oil engines which has a once-only action and must be re-selected every time the governor withdraws the rack is now optional on Simms fuel pumps sizes "A" and "BN." The action of the device can be followed from the diagram, which shows the normal running condition in which the stop lever, *A*, acts as the full fuel stop. Turning the knurled outer cover *F* clockwise through 45 deg. causes the peg *E* to depress the baulk lever *D* and push the stop lever off the end of the control rod *C*: forward movement of the rod is baulked by lever *D*. When the cap is released, the baulk lever rises, but the stop lever is restrained by the spring-loaded plunger *B*: when the baulk lever uncovers the control rod, the governor spring can force the rack into the excess fuel position, defined by the length of plunger *B*. When the governor withdraws the control rod, the stop lever springs up to its original position.

With a device such as this, excess fuel cannot be selected permanently, and if power beyond the normal limit were required in emergency a selection at the fuel pump, possibly by remote control, would be necessary.

line of which is offset in respect to the motor. A bushed extension of the pulley spindle is carried on the horizontal shaft, which thus acts as an additional thrust support along which the pulley spindle can slide in either direction.

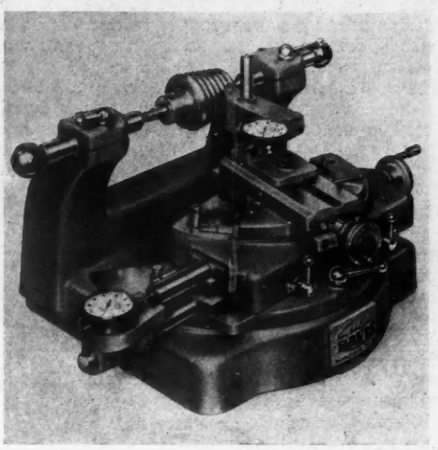


Variable-speed vee-belt drive unit in which belt tension is adjusted automatically in accordance with driving pulley setting

A hand wheel operated screw in the motor support base moves the motor in its guides towards or away from the driven unit, taking the pulley assembly with it. The outer, or sliding, flange of the pulley being coupled to the offset shaft, moves at a divergent angle to the motor slide, causing the pulley flanges to open or close to vary the ratio of the drive. With this combination of motor and pulley movements a constant tension and alignment of the belt is maintained irrespective of the speed ratio selected.

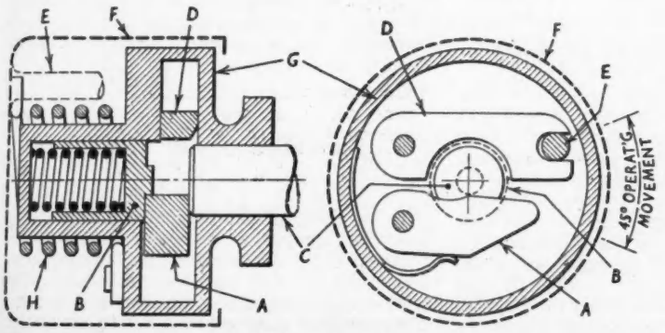
the accompanying illustration. The checking unit is mounted on a cross slide which is carried on a swivel table and by using a slip gauge the table can be set to the required angle.

For measuring purposes, the machine is set

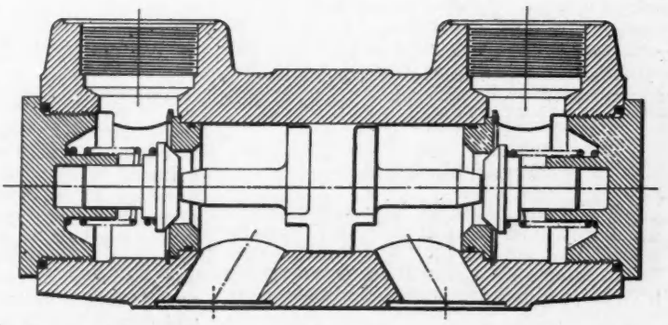


Flank angle checking machine

at zero with the pivot of the indicating head adjusted to set the stylus on the axis of the work-piece centres. For checking fine pitches the stylus point is placed on the axis of rotation. For checking helicoids, &c., which are straight sided in the axial plane, the same setting applies. Involute helicoids may be checked by setting the stylus above the work axis by an amount equal to the base circle radius and the swivelling table set to the base head angle of the work. The bias of the stylus is set according to the hand of the worm helix.



Both forward selection and backward spring return motions are necessary to obtain excess fuel



The lock valve shown here bolts directly on to a control valve and prevents any flow out of the motor circuit when "neutral" is selected

Variable Speed Belt Drive

AN improved form of the variable speed drive in which a vee belt is moved up or down between the flanges of a pulley to vary the speed of a driven shaft has been introduced by Industrial Drives, Ltd., 44, Uxbridge Road, London, W.5. This drive is designed to overcome the disadvantage of loss of belt tension experienced at different speeds, particularly in the lower ratios, when the centres of the driving and driven shafts remain at relatively fixed distances. It incorporates a positive means of adjusting the distance between the driving and driven pulley shafts in accordance with the position of the vee belt in the driving pulley.

One of these driving units can be seen in the photograph we reproduce, and they are available at present for use with motors from ½ h.p. to 15 h.p.

The motor bed plate is mounted on guides which are set at a predetermined angle relative to the horizontal axis of the motor. These guides are set in a casting to which a bracket is bolted on the pulley side. At its outer end the bracket is bushed to receive a vertical pillar upon which is mounted a plate, and this "T" form assembly has a limited movement about the centre line of the vertical pillar. A bracket on the plate supports a horizontal shaft, the centre

In these units the height of the horizontal pillar assembly is adjustable to suit the size of motor employed, and the offset angle can be set to give the most desirable rate of opening or closing of the pulley in relation to the number of turns of the hand wheel.

Flank Angle Checking Machine

A FLANK angle checking machine which can be used to check by direct measurement the form of involute helicoids and helicoids which have straight sides in the normal or axial planes, is now being made by Stuart Davis, Ltd., Much Park Street, Coventry. It measures on the principle that standard worm thread flanks are theoretically helical surfaces generated in a straight line. Parallel and taper hobs, helicoid involute forms, angle or straightness of flank forms, and pitch, can be checked on the machine. It takes work 9in between centres up to 4in diameter with a maximum pitch traverse of 4in, a maximum taper of 60 deg. in diameter, a maximum flank angle (to outside diameter, including taper work) of 45 deg., and a maximum flank angle to axis of centre of 15 deg.

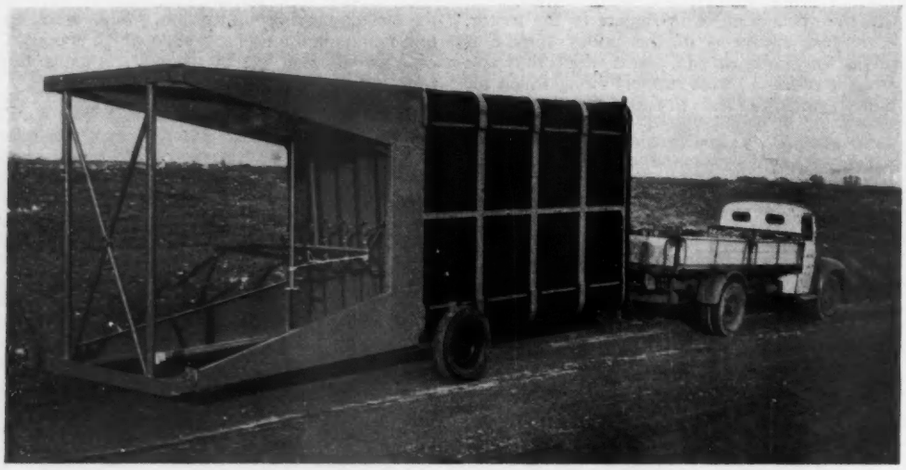
The stylus of the machine actuates an indicator with a 5 to 1 magnification which records any deviation from a straight line generator when brought into contact with a flank as shown in

Hydraulic Lock Valve

WE illustrate a lock valve that is manufactured by Dowty Hydraulic Units, Ltd., Ashchurch; it isolates a ram or motor positively when supply pressure is cut off. The principle of operation will be apparent from our illustration; when pressure is applied to either of the ports in the bottom of the valve, the poppet on that side will lift against its spring, and the poppet on the other side will be lifted by the movement of the piston; the motor then functions in the normal manner. Clearly, this valve cannot, like the maximum-flow shut-off valve, act to limit the speed at which a load is driven down when it is installed as a safeguard against the load dropping after hydraulic failure.

Since there is a pressure drop across the piston only when the circuit is in operation, fluid leakage past the piston is not critical. For circuits in which single-acting rams are used, the lock valve can be converted to a three-way fitting by blanking off one of the top ports.

The lock valves have been designed for use with the maker's "CV" series control valves, and have the same performance characteristics. Sizes 1, 2 and 3 are suitable for pressures up to 2500 lb, 2000 lb and 1500 lb per square inch and flows up to 7, 25 and 50 g.p.m., respectively.



The cement silo is considered to be completely mobile, and is shown here being towed, a normal 1-ton lorry being sufficient for this duty

Mobile Cement Silo

A CEMENT silo which can be towed behind a lorry and is claimed to be completely mobile has been introduced by Road Machines (Drayton), Ltd., West Drayton, Middlesex. Its capacity is in the range 20 to 40 tons, and the cement is controlled during discharge by aeration from a rotary blower which is built into the silo. The blower is driven by a 7·5 h.p. electric motor, or alternatively by a diesel engine ; it is claimed that only 5 h.p. is absorbed after starting up. There is also a weigh batcher—a weigh-beam device—for measuring out the cement, which can be operated automatically or manually.

A general idea of the construction of the silo is given by the accompanying illustration, where it is shown in the horizontal position, on tow behind a lorry. The silo has a steel frame, the four legs being of welded plate, with an adjustable base braced with steel tubes. The silo surface itself, however, is built of 15mm plywood ; plywood was chosen by the makers so as to obviate the possibility of condensation.

Hydraulic Seals

WE illustrate below an improved hydraulic seal known as the "Seatrist SCN-Ring" made by Ronald Trist and Co., Ltd., Bath Road, Slough, Bucks, in some fifty standard sizes covering shafts from ⅜in to 9¼in diameter and for pressures up to 10,000 lb per square inch. In these sealing elements of smooth, oil-resistant, synthetic rubber, there are bonded two concentric backing rings of tough laminated fabric. With this construction fluid pressure is transmitted radially to the backing rings, so that they react immediately to changes of pressure and to small movements of the sealing surfaces, such as might be caused by side thrust or cylinder bore swell. As a result, the sealing lip and body are always fully supported and protected against extrusion wear.

The makers state that these rings can be used for both piston head and gland sealing ; each is a complete single unit seal and does not require adaptor or header rings. It is pointed out that space and machining costs are saved by the seal housings of simple non-adjustable design required with the rings.

Hydraulic sealing ring of synthetic rubber, incorporating two concentric backing rings of laminated fabric

Factory for Asbestos Products

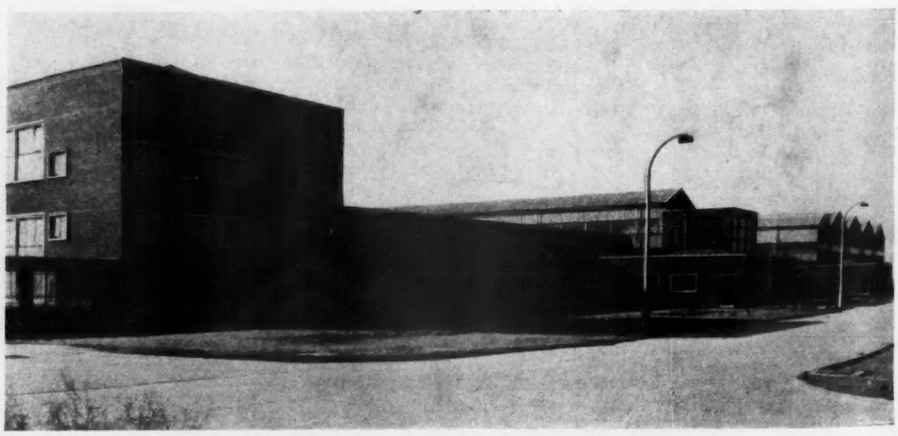
A NEW factory block, with a productive floor area of about 550,000 square feet, has been built and equipped for the manufacture of certain classes of asbestos textiles, glass textiles and resinated asbestos moulding materials at the works of Turner Brothers Asbestos Company, Ltd., Hindley Green, near Wigan. This new factory block, to be seen in the photograph we reproduce, adjoins one of a similar size which was completed in 1949 and is particularly concerned with the production of power transmission and conveyor belting. Its opening marks the completion of a works development project started in 1947 and costing about £4,000,000.

An increased productive capacity has thus been made available for asbestos textiles. A large proportion of these textiles are for brake lining materials, supplied to an associate company, Ferodo, Ltd., whilst others are supplied in various forms for fire protection, heat insulation, and other purposes. In the textile manufacturing section of the works the general flow of production starts from a large storage area for the bagged asbestos fibre materials on the first floor at one side of the building. An initial preparation plant for cleaning the fibres and batching them in accordance with the required specifications is situated at one end of this storage floor. From this plant the prepared batches of fibres are delivered to the ground floor where, on specially adapted orthodox textile machines, they are carded and spun into yarns, and woven into the required thicknesses and lengths for different applications. The looms used normally weave the asbestos up to 25in wide and 1in thick, although greater thicknesses can be woven if required.

Glass fibre material production follows a similar flow across the width of the building in an adjoining section. These "Duraglas" glass fibre materials are used to produce fabrics which are incombustible and resistant to most acids and alkalis.

The third main production line in the block is concerned with the manufacture of the firm's "Durestos" resinated asbestos thermosetting moulding materials. These materials in the form of felts, flocks and powders are used for the manufacture of high-strength mouldings which are resistant to heat and most chemicals. In addition to actual materials production development forms an important part of the new plastics materials section and it incorporates a large well-equipped research laboratory.

In the original factory block of the works a large section is now devoted to the manufacture of fire-resistant, anti-static P.V.C. conveyor belting, which is supplied in large quantities to the National Coal Board. In this section the fabric is first impregnated with P.V.C. in a continuous machine and then layered as required. The belt so formed is then passed on to a special curing machine where the edging strips are applied before the processing of successive lengths. At the outgoing end of the machine the sides are trimmed and the belt thoroughly inspected before transfer to the despatch department.



Newly completed block of the Hindley Green factory for the manufacture of asbestos textiles, glass textiles and resinated asbestos moulding materials

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Simplified Space Heating

THE "SALAMANDER"

In an article in our February 28 issue about the "Salamander" space heater made by ACE Heaters, Ltd., of Chapel Street, Liverpool, we stated that it would burn waste sump oil. This is so ; but it is subject to an important proviso. *Sump or other waste oil must not be used unless properly treated for the removal of water and other impurities.* We did draw attention to the essential safety precaution that water be not allowed to enter the bowl of the device since it would boil and expel hot oil. But we failed to point out that untreated waste oil is likely to contain water. We repeat, therefore, that untreated waste oil must not be used.

Industrial and Labour Notes

British Employers' Confederation

The annual general meeting of the British Employers' Confederation was held in London on Wednesday of last week. The annual report, reviewed in these notes in our last issue, was presented by the retiring president, Sir Colin Anderson.

During his speech, Sir Colin mentioned "a growing feeling that the threat to individual freedom which was inherent in our present industrial organisation was one which merited immediate attention." The nationalisation of an industry, he said, had meant that in that industry there was virtually only one employer. The right of an individual who wished to be employed in that industry was generally dependent upon his membership of a particular trade union, regardless of whether or not he wished to belong to that union. An honest difference of opinion between the individual and his workmates could and sometimes did lead to total exclusion from the employment in which a man might have spent all his working life. Although, Sir Colin went on, the risk of that happening was greater in the nationalised industries, it was by no means only in those industries that that kind of thing occurred. It was a problem that admitted of no easy solution, and it was perhaps best dealt with by the greatest possible ventilation of the facts when cases were found. Thus, the pressure of public opinion might be brought to bear. Such cases, Sir Colin added, were certainly not to be treated as purely domestic questions for the trade union concerned, or even for the trade union and the employers concerned. Fundamental rights were involved, which had not been subject to such a challenge in this country for many generations.

Dr. W. H. Garrett was elected to succeed Sir Colin as president of the Confederation. In a short address at the meeting, he said that, with the pace of technological and economic change accelerating as it was, members of the Confederation must expect constantly to be faced with new situations and difficulties and must be ready to deal with them as they emerged. New stresses and strains in industrial relations were bound to arise, Dr. Garrett continued, and members of the Confederation should ask themselves whether the arrangements in their industries were as efficient as they could be made for dealing with those matters which employers entrusted to industrial organisations. Equally, he commented, the Confederation should challenge itself as to whether it was doing all it could and should do for those organisations. The time seemed already ripe for the Confederation to arrange another conference such as it held in the autumn of 1955 on the future of industrial relations. Proposals for such a conference would probably be put before the council shortly, with a view to its being held next autumn.

Shipping Affairs

Mr. R. D. Ropner, in his presidential address at the eighty-first annual general meeting of the Chamber of Shipping of the United Kingdom, commented on the role of shipping and the degree of its adaptability to meet changing domestic and international conditions. He referred to the change from a free trade to a protectionist country and the possible difficulties of a limited area of free trade in Europe, and went on to suggest that alterations in market conditions must have considerable effect on the pattern of trade. The hardest practical problem, Mr. Ropner continued, was that of the flag of convenience. Based on current trends, he estimated that within ten years it would be possible for 30,000,000 gross tons of shipping to be flying the Liberian flag, so that Liberia would take the lead as a maritime country. The 40 per cent investment allowance, although welcome, did not put British shipping in a competitive position with those enjoying almost freedom from liability to tax.

Under favourable market conditions coupled with a continuous programme of replacement, Mr. Ropner said, the competitive position was not too adverse, but, he added, smaller firms not having a steady building programme were not so fortunate and so were at a great disadvantage compared with the untaxed owner. Thus, he thought, British shipping must steadily lose ground unless a solution was found. Commenting on the slump in freight rates, Mr. Ropner mentioned the losses involved and related this position to the building commitments of British owners which stood at a total of 6,500,000 gross tons of ships to be delivered in the next four years at a cost of over £900 million.

Gas and Electricity

The Parliamentary Secretary to the Ministry of Power, Sir Ian Horobin, made an announcement on Monday about the committee which is to investigate means of improved co-operation between the gas and electricity area boards. The committee's terms of reference, Sir Ian said, were: "to consider ways in which, by co-operation between the area and Scottish electricity and gas boards in the performance of their respective statutory functions, the administration of the services of a like kind provided to the public by the two industries might be improved."

The committee, Sir Ian stated, would consist of Sir Cecil Weir (chairman), Mr. R. R. B. Brown, Mr. G. le B. Diamond, Sir Edward Herbert, Sir John Imrie, Sir Henry Jones, Mr. C. T. Melling and Mr. Austin Morley. Another appointment was being made and would be announced in due course. The committee's report, Sir Ian added, would be presented to Parliament in the usual way.

Small Engineering Works

In a paper on "Batch Production of Agricultural Machinery," presented to the Institution of British Agricultural Engineers last Tuesday, Mr. P. W. Lester emphasised that the small factory must be constantly on the alert to use any new idea to aid production. It should be possible, he urged, for suggestions from the shop floor to be communicated direct to the designer draughtsman.

Nor, Mr. Lester continued, should the effect on personnel be overlooked. Discussing the differences between mass and batch production, he said the competition for labour between the two systems was constant. But the man who wished to retain his ability to use initiative would more often choose the smaller factory, knowing that the conditions of employment were similar and that there was little difference in pay, pension schemes and holidays. In the small factory engaged on batch production the operator would often use different kinds of machines in the course of the working week; that, together with the extent to which he must use his own initiative and accept responsibility, provided him with the variety which was essential to maintain the interest in the work he was doing. The small factory, Mr. Lester observed, was usually free of labour trouble because of that interest and because of the free and easy contact with the management, who were often on the shop floor and working with the men on a machine or project. That was something which gave mutual understanding of each other's problems and would lead to a contented and happy relationship.

Engineering Applications of Automation

About a year ago, a number of engineering institutions decided, after consultation, that the time was appropriate for the establishment of an organisation to be known as the British Conference on Automation and Computation. The principal object of this organisation is to make provision for the exchange of information about the activities of the individual societies in so far as they relate to automation and computation. The organisation has now been divided into three groups, namely, engineering applications of automation; computation and automatic control; sociological and economic aspects of automation techniques.

The first of these groups was formally constituted, at a recent meeting in London, as the British Group for the Engineering Applications of Automation. The principal objects of the group are to foster the development of the engineering applications of automation; to afford a common meeting ground for the adhering organisations, whereby such of their activities as fall within the purview of the group can, if so desired, be co-ordinated and extended, and to encourage and maintain liaison with the corresponding national committees of other countries. Dr. D. F. Galloway (Institution of Mechanical Engineers) has been elected chairman of the group. The secretarial services are being undertaken by the Institution of Mechanical Engineers, Mr. Brian G. Robbins, secretary of that Institution, having been elected honorary secretary of the group.

Coal

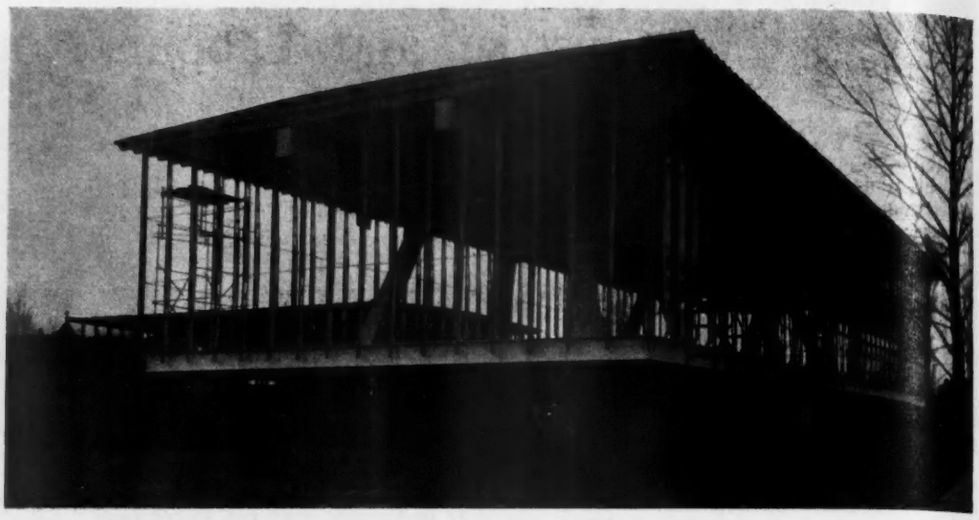
In the first ten weeks of this year, ended last Saturday, coal production in this country amounted to 44,238,400 tons. That total included 41,849,000 tons from the deep mines and 2,389,400 tons from opencast workings. In the comparable period of last year, production amounted to 46,136,700 tons. This year, so far, deep-mined output has fallen about 2,000,000 tons behind that achieved in the corresponding period of last year.

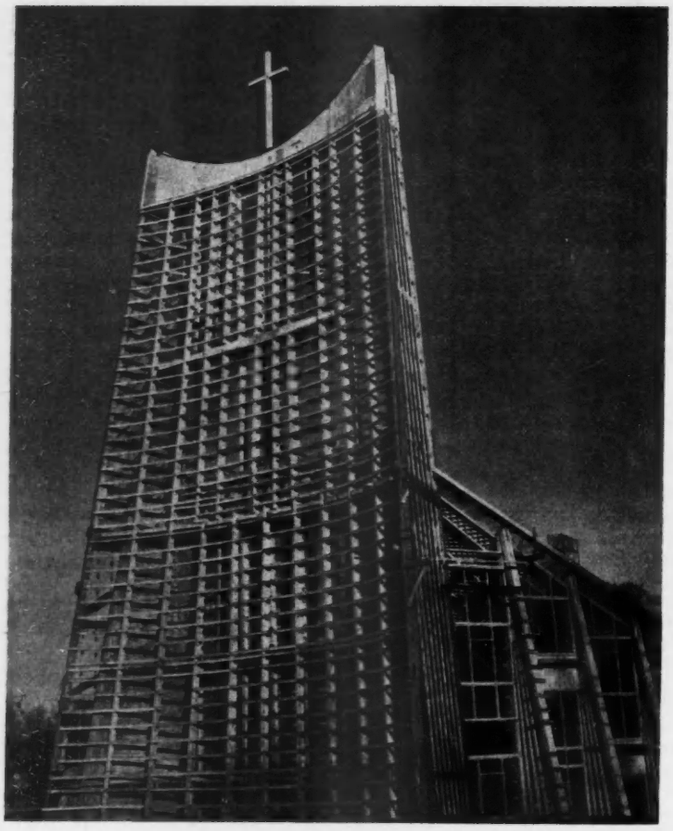
Colliery manpower on March 1 was returned as 710,500, of whom 276,700 were faceworkers. A year ago there were 279,800 faceworkers. The figure for shifts worked per wage-earner, at 4·76, is slightly below that for last year, and the total absence percentage, 15·11 per cent, during the first nine weeks of the year must be compared with 13·06 per cent in the corresponding period of 1957. Inland coal consumption in the first nine weeks of the year amounted to 42,234,000 tons and export and bunker requirements were 968,000 tons. Coal imports in the same period were 295,900 tons compared with 548,300 tons last year.

Progress in Brussels

Preparations for the Brussels Universal and International Exhibition, 1958, due to open on April 17, are in full swing at the Heysel and Belvedere gardens, on the north-western outskirts of the city. Elsewhere in the Belgian capital, traffic improvements in the shape of widened roads, tunnels, and fly-overs are being completed, and in order to accommodate the 35,000,000 visitors expected during the six months of the Exhibition, hotel and "motel" space is being expanded.

Work at the Exhibition's grounds was financed by a Government loan of 1200 million francs, issued in March, 1955,

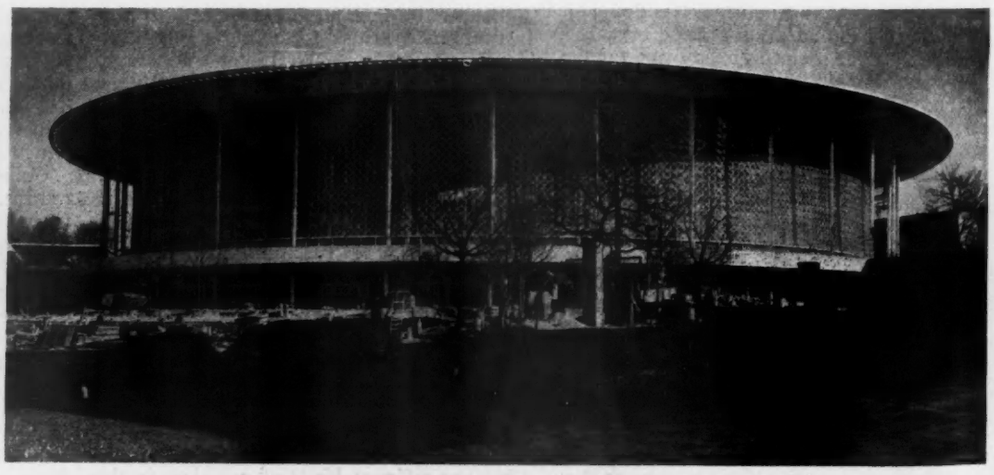


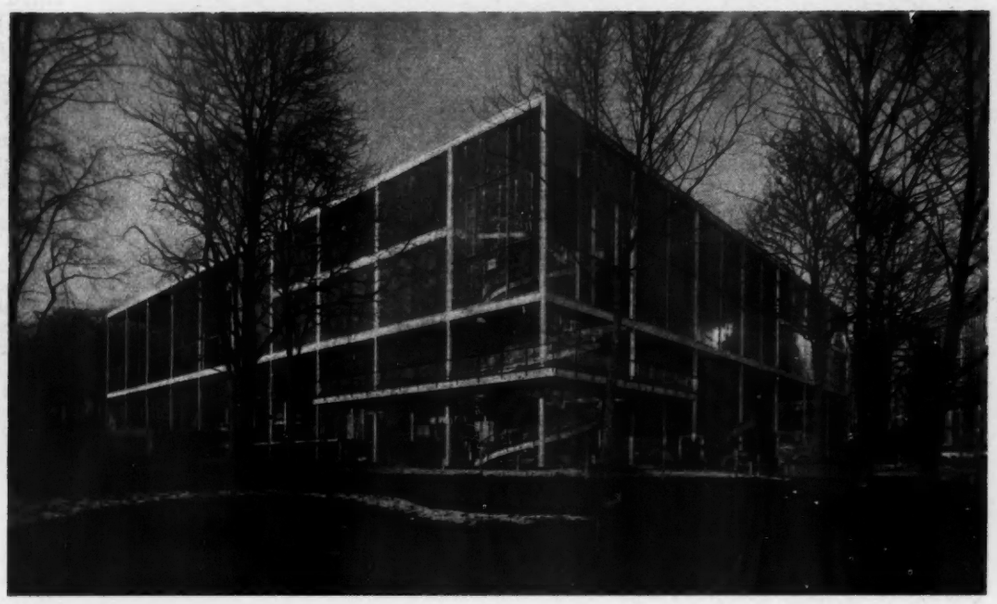


and fully subscribed in one day. The bonds, which were of a face value of 1000 francs each, bear interest at 2 per cent until redeemed at par in 1960. In the meantime, they are eligible for cash prizes ranging from 5,000,000 to 50,000 francs tax free, thus bringing the effective interest rate up to 4·6 per cent.

In order to take care of the influx of visitors a special organisation, Logexpo, 35, rue Belliard, Bruxelles (telephone, 13.29.94), has been called into being, which, with the help of electronic machines, will undertake to make bookings within a minimum of time. In addition to hotel rooms, the fullest use will be made of private accommodation and it is hoped to make available in this way a minimum of 10,000 beds. In the vicinity of the exhibition, camping and caravan space is being provided. Since the capital is within easy reach from most parts of the country, full use will be made of provincial centres to supply reserve accommodation.

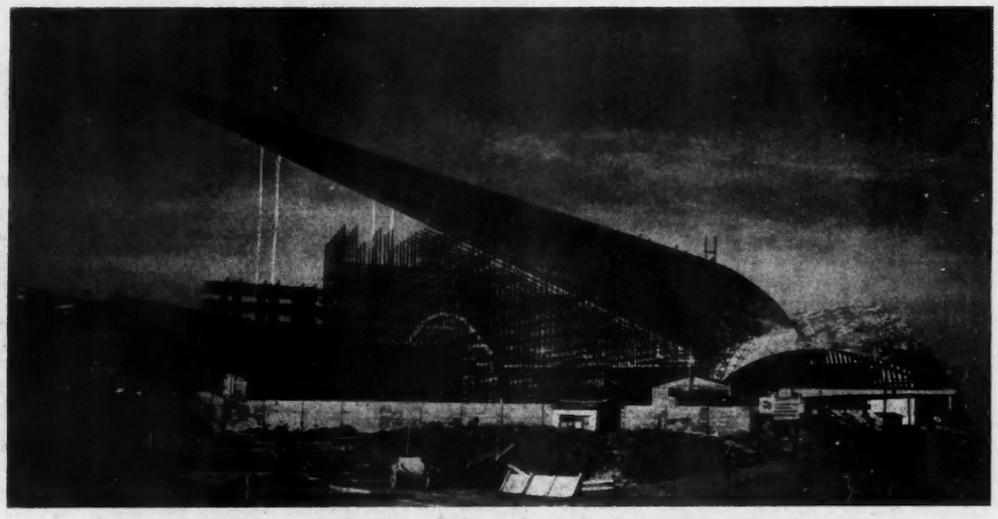
The road programme in Brussels itself and elsewhere in Belgium amounts to 1000km of new construction and 6000km of improvements. Arrangements are being made on an international scale to increase train and air services. In connection with the latter, a helicopter terminal, or "heliport," is being completed, where all normal helicopter services to Melsbroek airport and the Brussels city heliport "Allée Verte," will land. Since about three minutes will be allowed for each helicopter to disembark and take on board passengers, this will mean that about 100,000 landings will be made during the Exhibition. The Sabena helicopter fleet at present comprises eight Sikorsky "S 58" machines, each capable of carrying twelve passengers. The "Allée Verte" heliport, situated five minutes from the city centre, has three landing platforms, each 82ft in diameter. It is being enlarged by the addition of a new terminal building, 147ft by 65ft, extending into a "finger," 312ft by 27ft. The heliport at the Heysel will also have three landing platforms and a terminal building containing a restaurant. The reason for the size of the Heysel facilities being nearly as big as those in the city centre is that they will also be available for local pleasure flights, and it is thought that half the total number of flights will be in that category. Still in the domain of traffic improvements is the new tunnel for suburban trams, which is 400m long and involved the placing of 8000 cubic metres of concrete and 1000 tonnes of reinforcements. It was constructed in the short space of seven months. Within the Exhibition, visitors will have at their disposal a three-line aerial chairlift over 4km long, over which 165 two-seater gondolas will travel at a speed of 2m per second. Provided with four stations, the chairlift will have a daily capacity of 75,000 to 100,000 passengers.

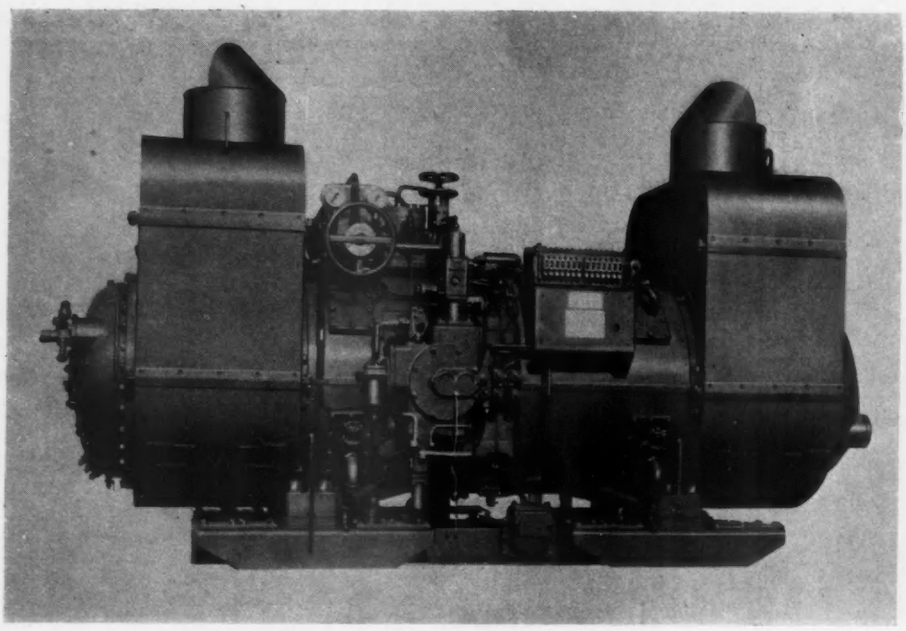




In the course of a recent visit we were able to confirm the great progress which is being made and the effort which is being expended to get everything ready in time. Much interest will be centred on the halls and pavilions themselves, and on other structures, most of which afforded full scope to the imagination of the architect and the ingenuity of the engineer. In particular, mention may be made of the "Atomium," a model of a body-centred cubic crystal to a scale of 1·5×10in, standing on one diagonal, and rising to a height of 110m. The nine spheres at the corners and centre of the cube are 18m in diameter and clad in bright aluminium sheeting. The framework, representing the valency bonds of the crystals, consists of steel tubes of 3m diameter and 6mm thick, provided with stiffeners; the central tube having walls 12mm thick. The structure, which has a weight of 2300 tonnes, is steadied by three pairs of box-section columns which also carry access staircases. Another remarkable structure is the "Civil Engineering Arrow" (bottom right), consisting principally of an 80m long cantilever beam and counterbalancing portion, the whole standing on three supports. The "Arrow" has an inverted A section of 4cm to 12cm thick shell concrete. From it a footbridge 58·5m long by 2·5m wide will be suspended about 5m above ground level. Underneath, a large-scale relief map of Belgium will be laid out showing the main civil engineering works of the country. In the Belgian part of the Exhibition, for reasons of economy, many of the halls dating from the 1935 Exhibition are being used again. Among the new buildings must be mentioned Halls 11 (433m by 42m free span) and 7 (150m by 70m span). The latter, of which an interior view is shown on the left, has a vaulted roof supported on a series of welded portal frames. The roof takes the form of a trellis of profiles each 4·25m long, while the facades are built up from prefabricated concrete blocks. At the top of the page is the nearly complete pavilion of Canada. A particularly successful example of the use of wood is the Vatican building (second illustration on preceding page), while the Luxembourg pavilion (top of preceding page) by way of illustrating the Grand Duchy's steel production—12 tons per head per year, compared with 0·2 ton in Germany and France—is constructed of that material. Measuring 52m by 21m, its walls and floor are suspended from portal frames, which also support the roof. The total steel weight is 535 tons. One of the largest exhibition buildings is that of the United States (bottom of preceding page), which is a circular structure of 381ft diameter at roof level, and 85ft high, covering an area of 114,200 square feet. The roof consists

of a flat ring carried by two rows of thirty-six columns. Suspended from this ring by two sets of cables is a central cylindrical ring, 62ft 6in in diameter and 23ft high. The ceiling is of expanded metal and glass-fibre-reinforced polyvinyl chloride sheet. At first-floor level is a balcony in the form of an annular concrete slab, supported by four rows of thirty-six tubular columns 16in in diameter, the outer two rows being continued upwards with a 12in diameter column to support the roof. The outer wall of the building is formed by a plastic-covered steel trellis. The structure has a steel weight of 1539 tonnes.





1000 h.p. free piston gas generator

German Gas Turbine Vessel

The first German ship to be fitted with free piston gas generators and gas turbine was completed recently. It is the trawler "Sagitta," of 720 gross register tons, belonging to Fisch Reederei Busse, Bremerhaven. Built by Rickmerswerft, Bremerhaven, the vessel is similar in design to a diesel-powered sister ship, its main dimensions being, length 67m, beam 9·6m, fresh fish hold 450 cubic metres, deep freeze hold 90 cubic metres, design speed 15 knots. The ship has a stern ramp for hauling the catch on board by a hydraulic winch. From the ship it is discharged into a bunker on the deck below, from where the fish are taken to be gutted, after which a belt conveyor brings them to the washing machine. From there a distributor conveyor deposits the catch in the fresh fish hold. Of special interest is the propulsion plant, supplied by the firm Modag, Motorenfabrik Darmstadt, G.m.b.H. Two free piston gas generators (licence SEP—SEME—SIGMA, see accompanying illustration) supply a gas turbine which drives through reduction gearing a variable pitch propeller. The gas generators burn Bunker "C" fuel, each operating at the ratio of 600 strokes per minute. Entry conditions at the turbine are 430 deg. Cent. and 3 atmospheres gauge. The turbine runs at 8000 r.p.m., which speed is geared down to 250 r.p.m. at the propeller shaft. At the turbine shaft, 2000 h.p. is available, of which 10 per cent is lost in the gearing or used for generating electrical energy. The gas generators are started up with compressed air, and if operated from cold are run for the first half hour on gas oil, the second half of this period at full load. They can then be switched over to full-load operation with Bunker "C" fuel. The gas generator injection pumps are controlled by the power requirements at the turbine ; the generators continue to operate during reversal of the propeller, or in the case of a solid propeller, while the propeller shaft is being reversed. Including the reduction gearing, the whole engine installation, without auxiliary engine, weighs about 35 tonnes. Overall thermal efficiency is stated to be 37 per cent.

International Apprentice Competition

In July this year an International Apprentice Competition is to be held in Brussels during the International Exhibition. This is not the first time such a competition has been held. The competition began in 1947 as a purely Spanish venture, to select by means of a series of local, regional and national competitions, the best Spanish apprentice in each of various trades. This was extended in 1951 when the winners in Spain competed against boys who had come through a similar series of tests in Portugal. The competition was then opened to any other country which wished to participate. A single competitor went from Britain in 1955, six in 1956 and twelve in 1957.

The governing body, whose seat is in Spain, is the "Organising Committee of the International Vocational Training Competition," which consists of a president, vice-president and secretary and an official representative from each participating country. This organising committee is responsible, among other things, for deciding when and where the competition shall be held, what trades shall be included and how the competition shall be conducted.

In 1956, a meeting of interested organisations was held in London, as a result of which a small committee known as the "British Organising Committee," was established to make arrangements for selecting a team in this country. Each of the participating countries is free to submit drawings for the tests to be undertaken by the apprentices during the competition.

These are considered by the international organising committee, which makes its selection immediately before the competition. The tests are not made known to the apprentices until the competition starts and range up to forty hours in length.

During the competition interpreters and officials are constantly in attendance so that any boy who finds himself in difficulties can immediately ask for their assistance. Last year the test drawings were marked in both linear and metric measurements for those apprentices who required them. The results are judged by a panel of technical representatives, one from each of the participating countries.

The British Organising Committee hopes that as many firms and other organisations as possible will take an interest in the competition and submit the names of suitable candidates for consideration for the British team. It is also hoped that firms employing apprentices who have done well in recent City and Guilds of London Institute Examinations will also nominate these boys for selection. A firm sending a boy to the competition is required to pay the cost of travelling only. The host country pays all the costs of the apprentice's stay during the competition. Each of the trades is divided into two categories for the purposes of the competition. Category "A" will be for boys born in 1937, 1938 and 1939, and Category "B" for boys born in 1940, 1941 and 1942. No country can have more than one competitor in each age category for each trade. Any firm wishing to submit the names of boys for possible inclusion in the British team should write to, Director (A.C.), City and Guilds of London Institute, Gresham College, Basinghall Street, London, E.C.2.

Third Congress of the International Federation of Prestressing

The Prestressed Concrete Development Group has announced details of the third Congress of the International Federation of Prestressing (F.I.P.) which is to be held in Berlin from May 5 to 10 this year. The technical sessions will take place in the Benjamin Franklin Memorial Hall, and will comprise four working sessions, dealing with : development in design methods (general reporter, Professor Dr.-Ing. H. Rüsch, Munich ; British reporter, Mr. A. J. Harris) ; progress in prestressing technique as applied on the site (Dr.-Ing. F. Janssonius, Amsterdam ; Dr. S. Champion, Mr. R. B. Hill) ; the manufacture of factory-made precast prestressed concrete units and their assembly on the site (Mr. D. H. New, London ; Mr. J. W. A. Ager, Mr. E. W. H. Gifford) ; prestressed structures executed since the 1955 congress and embodying important developments (Monsiur Dumas, Lille ; Mr. R. F. Galbraith, Mr. A. W. Hill). Arrangements have been made for the translation of discussions in the four official congress languages, which are English, French, German and Spanish.

In addition to the technical sessions, delegates will have the opportunity of visiting a number of outstanding structures which are in course of construction in the vicinity of Berlin. Special arrangements will be made for those who wish to visit the buildings constructed as part of the Interbau Exhibition. A copy of the programme and further details may be obtained from Philip Gooding, Prestressed Concrete Development Group, Terminal House, Grosvenor Gardens, London, S.W.1.

Bearing Metals from Holland

A new bearing material marketed under the trade name of "Kufaleyt BWH" was among the exhibits seen at the International Macroplastic Fair held in Amsterdam in November last. This material is made by N.V. Mekufa, Vroomshoop, Linderflier 43, Netherlands. It is an epoxide resin impregnated with graphite and unlike nylon has a very low water absorption. Immersion in water at 20 deg. Cent. for ten days results in an increase in weight of only 0·25 to 0·35 per cent, and swelling is negligible. The inclusion of graphite in the compound makes lubrication practically unnecessary. Values for coefficients of friction quoted for steel on "Kufaleyt BWH," measured on a thrust bearing with water lubrication, are μ=0·01 to 0·02 at an axial load of 300 kg ; μ=0·003 to 0·005 at an axial load of 1000 kg.

Other data given to us, relevant to the use of this material for bearings, include a thermal conductivity of approximately 0·2 k. cal. per square millimetre per deg. Cent. per hour ; a bending strength of 1000 kg per square centimetre, and a tensile strength of 700 kg per square centimetre. "Kufaleyt BWH" is claimed to have such chemical resistance that it can be used for bearings exposed to aggressive vapours and liquids. Exposure at 20 deg. Cent. for six months, to 10 per cent hydrochloric acid, 60 per cent sulphuric acid, 10 per cent caustic soda, and petrol, has little effect. For this reason the main applications of "Kufaleyt BWH" bearings are expected to lie in the chemical and allied industries, but a considerable market has already developed on the Continent in the textile and paper industries.

Ludwig Prandtl Memorial Lecture

In 1956, the Wissenschaftliche Gesellschaft für Luftfahrt (WGL), Brunswick, and the Gesellschaft für Angewandte Mathematik und Mechanik, decided to honour the memory of Ludwig Prandtl by annual memorial lectures. This year's event will take place on May 7 in the Concert Hall of the German Museum in Munich, which earlier on the same day will be celebrating in the course of its annual meeting the reopening of its Aeronautical Section. The guest speaker will be Dr. Hugh L. Dryden, director of the National Advisory Committee for Aeronautics, who will speak on "Present-Day Problems in Aeronautical Research." The occasion will be marked by the award, for the second time, of the Ludwig-Prandtl-Ring.

Progress of the Tennessee Valley Authority

BY OUR AMERICAN EDITOR

No. II—(*Concluded from page* 377, *March* 7)

River Navigation

ALTHOUGH flood reduction was the outstanding aspect of the water control programme in the past year, operations for other purposes were also carried on with satisfactory results. At the beginning of the fiscal year, the reservoirs contained 7,910,000 acre-feet of useful water in storage, and of this total 85 per cent was in the tributary reservoirs and the three mainstream reservoirs above Chickamauga dam. When the year ended, there were 7,760,000 acre-feet of water in storage, a reduction of 150,000 acre-feet or 2 per cent during the year. About 83 per cent of the stored water was in the reservoirs upstream from Chickamauga dam. Both rainfall and run-off were more plentiful during the fiscal year, after a long period of sub-normal precipitation extending from the spring of 1952 into early 1965. However, distribution was uneven, since 22in or approximately 40 per cent of the 55·7in total rainfall occurred in the three months from December, 1956, to February, 1957, inclusive.

Thus the system had to be operated to allow for considerable periods of low flow as well as flood conditions. Subnormal natural flow persisted at Chattanooga until November, 1956, which was the driest month of the year and the seventh dry month in succession. Stored water was drawn upon heavily to support hydro-electric production. This withdrawal continued until mid-December and at some of the reservoirs until mid-January. By this time the tributary reservoirs had been drawn down, as has been noted before, to levels below those required for flood control.

However, they were not as low as in the previous year. During the flood, storage was replenished. After the flood period all the tributary reservoirs, taking advantage of favourable rainfall conditions, continued filling until May with little draught upon them for power production.

Dependable 9ft navigation in the Tennessee River was maintained by holding the mainstream reservoirs at or above the minimum levels for this purpose, with the discharges at the tributary dams in addition to turbine operations being arranged to afford a sufficient water supply. On some occasions, special operations were necessary to refloat barges, towboats and other craft stranded outside the navigation channel. For malaria control, the water levels were fluctuated and gradually drawn down in the mainstream reservoirs in the summer and autumn of 1956, with satisfactory results in helping to reduce the propagation of mosquitoes. The beginning of the autumn draw-down of the Fort Loudoun and Watts Bar reservoirs, farthest upstream of the mainstream chain, was delayed for two months for experimental purposes.

Freight traffic on the improved Tennessee waterway in 1956 continued its sharp upward trend, exceeding the 1955 traffic by 23 per cent both in tons and ton-miles. An estimated 12,300,000 tons of freight, representing more than 2000 million ton-miles, moved on the river during the year, The users of the waterway saved more than 20,000,000 dollars in freight bills as compared with the next cheapest available mode of transport. Several new cargo movements, including liquid chlorine from Wilson Dam, pig iron between Rockwood and Chattanooga, soil pipe and fittings from Chattanooga, started during the year. There were special shipments such as mine railcars from Knoxville to Barker, Pennsylvania, and phosphate rock from Florida to Wilson Dam. Coal shipments in 1956 amounted to more than half the total traffic and exceeded 1000 million ton-miles.

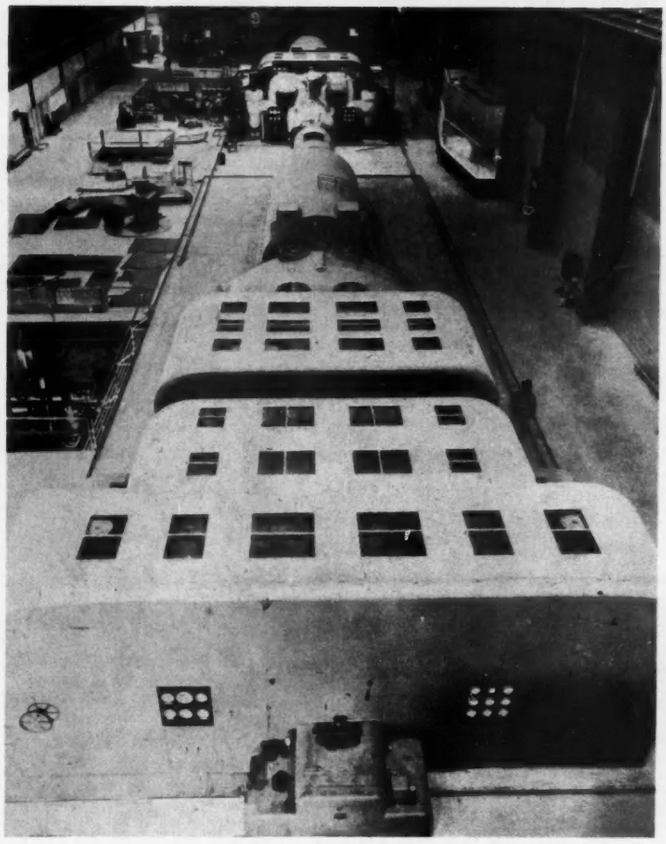


Fig. 6—225MW turbo-generator at the Gallatin steam power station

Power Generation

Power deliveries to the Atomic Energy Commission plants and other Federal installations, which have multiplied nearly sixteen times since 1951 and have accounted for well over half of the Authority's outside power sales in each of the last three years, increased but little during the fiscal year 1957. Other uses of electricity in the T.V.A. region continued their sharp upward trend. The total sales of electricity by the T.V.A. amounted to 57,000 million kWh, as compared with 53,800 million kWh in 1956.

On June 27, 1957, T.V.A. placed in commercial operation the second 225MW capacity generating unit at the Gallatin steam power station. This brought to completion an extraordinary programme of expansion of generating capacity for direct defence needs, started in 1950, when the A.E.C., as a result of the Korean conflict and the general international situation, began a programme of rapid construction of new atomic defence facilities in the Tennessee Valley region. The A.E.C. facilities included a heavy expansion at Oak Ridge and an entirely new plant near Paducah, Kentucky. The A.E.C. has long-term contracts with T.V.A. for a total of 3125MW of power. Since works using electricity can be constructed much more rapidly than electric generating facilities to serve them, T.V.A. also has been supplying interim power from various sources. The sources included some of the older plants and power obtained from other systems. T.V.A. has also been supplying about 500MW of "extended load" at the A.E.C. plants, over and above the long-term contract demands. The revenues from sales to the A.E.C., including power sold under long-term contracts and the relatively more expensive interim and "extended load" deliveries, averaged 0·4 cent per kilowatt-hour during the year.

The adverse conditions which affected the T.V.A. generation during the previous five years —poor water conditions, delays in manufacture of generating units, occasional difficulties in coal supply—were largely absent or reduced to reasonable dimensions during the 1957 fiscal year. The total power delivered to the grid system during the year amounted to about 63,200 million kWh. Of the total, 44,700 million kWh, 4 per cent more than the year before, came from steam-electric plants. Hydro-generation increased 16 per cent, providing 16,700 million kWh. Of the hydro-electric energy, 13,400 million kWh came from T.V.A. projects, 1400kWh was obtained from the United States Army Engineers' multi-purpose dams in the Cumberland Basin, and 1900kWh was generated by plants of the Aluminum Company of America. In addition to the generation of 61,400 million kWh, T.V.A. received about 1800 million kWh from other power systems. Of the total input, T.V.A. sold 57,000 million kWh, about 1800 million kWh was delivered to Alcoa in return for power generated at its dams, and about 2000 million kWh of input was accounted for by transmission losses.

The conditions for hydro-electric generation generally were good. They were moderately below average until near the end of January, and thereafter were, on the whole, excellent. At the beginning of the fiscal year, the reservoirs were filled to 72 per cent of the storage provided when filled to their normal maximum levels. The water in storage represented about 5100 million kWh. This water was used in the regular annual draw-down which supplements natural stream flows for power production and navigation and, at the same time, lowers the reservoirs to the required flood control levels by January 1. However, the heavy rains normally expected in January were delayed for several weeks, causing some concern. Heavy rains began on January 21 and continued for twenty-one days, with only one interruption, producing the major flood described earlier. Within a few days after the storm began, the reservoirs were back to the normal levels for the season and thereafter power operations were affected by flood regulation operations.

During the period of this flood regulation, continuing until the end of February, the hydro system was used for base-load operation, reversing the normal roles of water and steam power on the system. With more than ample water, daily hydro-electric generation averaged 26 per cent greater in February than for any previous month in T.V.A. experience despite capacity reductions due to high tail-water which reduced the operating head. The maximum hourly generation by the hydro-electric system in February was 3285MW and the average for the month was 2960MW.

Although the heaviest demands of the year occurred in January and February, fortunately they did not come at the times of greatest capacity reductions. Minor curtailments in loads were made and small amounts of power were secured from other systems in order to avoid starting up Watts Bar or other less efficient steam power stations. After the flood period, the water conditions were generally favourable for hydro-

Fig. 7—Construction of river wall for the 110ft by 600ft lock chamber at the Wilson dam

electric generation during the remainder of the fiscal year, and cut-backs in generation were possible at some of the new steam power stations. In particular, this was true at Widows Creek, where generation could be curtailed in the four less efficient units which do not have a reheat cycle.

The steam-electric generating facilities continued to operate at high efficiency. For the second year in succession the average annual heat rate was well below 10,000 B.Th.U. per net kilowatt-hour generated. In the fiscal year 1957, the average rate was 9705 B.Th.U. per net kilowatt-hour, compared with 9780 B.Th.U. the year before. The national average in the calendar year 1956 was 11,400 B.Th.U. per kilowatt-hour. Because of the favourable hydro conditions it was unnecessary to operate the older and less efficient steam plants. Even the Watts Bar steam power station, which was built by T.V.A. during World War II, remained idle. The steam power stations burned 18,200,000 tons of coal during the year at an average cost of 19·35 cents per 1,000,000 B.Th.U. This was an increase of 3·6 per cent over the cost of coal in the previous year. Statistics on coal consumption during the year are shown in the following table :—

Power station	Tons of coal consumed	Cents per million B.Th.U. burned	B.Th.U. per kilowatt-hour net generation	Cents per kilowatt-hour net generation
Colbert	2,204,549	18·97	9,481	0·1799
Gallatin	608,478	19·07	9,632	0·1837
Johnsonville ...	2,368,924	18·23	10,152	0·1851
John Sevier ...	1,662,343	20·87	9,347	0·1950
Kingston... ...	4,698,506	20·72	9,577	0·1984
Shawnee... ...	4,792,684	17·59	9,821	0·1727
Widows Creek	1,904,155	20·56	9,837	0·2023

The gross income from power operations amounted to 235·7 million dollars in the fiscal year 1957, an increase of 14,100,000 dollars over the previous year. The net income from power operations was 58,100,000 dollars and represented a return of 4 per cent on the average net investment in power facilities of about 1470 million dollars. The rate of return was 3·9 per cent in fiscal 1956 and has averaged 4 per cent over the entire twenty-four-year period of operations.

The continued increase in the sales and use of electricity and the general financial success of the operations of the distributors emphasised the effectiveness of encouraging mass consumption through low rates, an aim incorporated in the T.V.A. Act. The congressional objective for T.V.A. power as set forth in the Act was that the projects were to be regarded " primarily as for the benefit of the people of the section as a whole and particularly the domestic and rural consumers to whom the power can economically be made available." It was contemplated that electricity should be sold " at the lowest possible rates and in such a manner as to encourage increased domestic and rural use . . . " In line with these principles. the basic rates at which power was distributed in the area were set at only about half of what the prevailing rates had been prior to T.V.A.

Low rates, the availability of electric service to more consumers, and electrical research and demonstration designed to encourage people to use electricity more effectively and abundantly, were counted upon to bring increasingly larger consumption. The increased use, in turn, has been a major factor in reducing the average rate to the consumer. The effectiveness of this approach to electricity distribution has been constantly reaffirmed with the passing years, and with the growth in power loads many of the distributors have been able progressively to reduce their rates.

The number of electricity consumers in the T.V.A. service area has doubled in the ten-year period from 1947 to 1957. The average residential consumption of electricity has increased 174 per cent to 6023kWh per customer in the fiscal year 1957. The average residential rate, influenced both by increasing consumption and reductions in rates, has dropped 0·51 cent to 1·15 cents per kilowatt-hour, a decrease of 31 per cent in ten years. Over the same period, the average residential use in the country as a whole increased 121 per cent to 3063kWh per customer, while the average rate per kilowatt-hour has gone down 0·56 cent to 2·58 cents per kilowatt-hour, a reduction of 18 per cent.

A total of sixteen distributors of T.V.A. power, the largest number to do so in a single year, authorised reductions in their rates to consumers through the adoption of lower schedules. Eleven systems, including two electric co-operatives, reduced their rates to the intermediate level, about 10 per cent below the basic level ; another five adopted a schedule of rates about 20 per cent below the basic rates. In addition, twelve systems removed the 10 per cent developmental surcharge from the bills of their commercial and industrial customers, three modified their street lighting rates, and nine removed the amortisation charge. Three systems removed both the surcharge and the amortisation charge. In all, thirty-five systems reduced the cost of electricity to their consumers. The total of such reductions in the first year of application was estimated at 1,800,000 dollars. Most of the reductions were effective during the fiscal year 1957, but some were to take effect in the following year. As the fiscal year closed, a total of sixty-three of the municipal and co-operative electric distributors and one small private utility had adopted rates below the basic level. Of the total, thirty-nine had adopted the intermediate level of rates and twenty-four the lowest schedule.

Construction Progress

Construction in the fiscal year 1957 centred on the new, large navigation lock at the Wilson dam and on ten generating units at four steam-electric power stations. The construction of the lock, which will remove a bottleneck for rapidly increasing traffic on the 650-mile Tennessee River navigation channel, was started as soon as funds became available at the beginning of the fiscal year. It was scheduled for initial operation in April, 1959, and completion in June, 1960. Three of the steam-electric generating units were completed and placed in operation during the year. They added 585MW of installed capacity and, with a 25MW unit placed in operation at the Old Hickory dam of the United States Army Engineers on the Cumberland River, brought the total installed capacity of the integrated power system to 9,889,485kW.

This was the smallest increment of installed capacity in any year since 1951, and only a little over one-third the record addition of 1734MW in 1955 when T.V.A. was at the height of the construction programme designed to meet the power requirements of the Atomic Energy Commission at its Oak Ridge and Paducah plants. At the close of the fiscal year, seven generating units were being added at three steam-electric stations. They will increase capacity by 1215MW over the next two and a half years, at a time when the demand for electricity is pressing hard upon the available supply.

Because the rising demand for electricity, and particularly the requirements of the national atomic energy programme, has far outgrown the hydro-electric resources of the region, construction during the past few years has been almost entirely in steam-electric capacity. While a few sites still remain for dams and reservoirs which would produce power as well as contribute to the several other objectives of water control, no large increase of hydro capacity such as the Norris or Fontana dams can be made. At the close of the fiscal year, the installed capacity of the integrated systems consisted of 3,602,235 kW in hydro-electric plants and 6,287,250kW in steam-electric plants. For the third consecutive year, T.V.A. had no dams under construction.

The need for the new lock at the Wilson dam had become critically apparent in the past few years with the rapid development of commercial traffic on the Tennessee River. The present lock facilities date back to 1925, when the Wilson dam was completed by the U.S. Army Engineers and provided a deep channel over most of the Big Muscle Shoals reach of the river. The shoals had been a bar to navigation on the river for a century. Previous attempt to by-pass the shoals by canals and locks had not been successful. The present facilities include lock and dam No. 1, providing a 10ft lift at the foot of the Muscle Shoals canal 2¼ miles downstream from the dam. At the dam proper, two locks in tandem provide a lift of 90ft. Tows going up or downstream thus must make three lockages to pass Wilson dam. The lock chambers are small, the lower one being 60ft by 300ft and the upper one 60ft by 292ft. Passage through this stretch, particularly for the multiple-barge tows now common on the river, requires hours of tedious lockage time.

The lock now under construction will provide a 100ft single lift in a lock chamber 110ft by 600ft, the same size as those at the Pickwick Landing and Kentucky dams downstream. When the new Wilson lock is completed, the river in its lower reaches will have three large locks. Above the Wilson dam, the locks at five T.V.A. dams—Wheeler, Guntersville, Chickamauga, Watts Bar and Fort Loudoun—are 60ft by 360ft in size. Another small lock, 60ft by 265ft, is in service at the Hales Bar dam below Chattanooga, and was acquired by T.V.A. in 1939.

The new Wilson lock is being built adjacent to the old tandem locks. The project includes deepening and widening the canal downstream, the elimination of dam and lock No. 1, and deepening of the lower chamber of the lock at the dam. The old locks at Wilson dam will remain to be used as auxiliaries to the new

installation. Construction progress was good during the year. At its close, excavation in the lock area was practically complete. The concrete mixing plant and the cement and aggregate handling systems were completed in June, 1957. One of the important contributions to speedy and efficient construction was the use of a lock model built and operated in the T.V.A. hydraulic laboratory. Through the use of this 1 to 16 scale model in experimental operation, the final solution of the main hydraulic design problems for the lock was obtained only a few weeks before concreting began. The estimated cost of the new Wilson lock, including canal improvements, is 35,000,000 dollars.

During the fiscal year, T.V.A. placed in operation three steam-electric generating units, one at the Shawnee power station on the Ohio River and two at the Gallatin power station, on the Cumberland River. At the end of the year, construction was continuing on two additional generating units at Gallatin, a fourth unit at the John Sevier power station in east Tennessee, and four additional units at the Johnsonville power station on the shores of Kentucky Lake in west Tennessee. Progress at the various construction sites is summarised as follows :

Shawnee.—The tenth unit at the Shawnee steam power station was placed in operation on October 12, 1956, under a temporary limitation in generating capacity to about 100MW. In June, 1957, after major modifications of the turbine were completed by the manufacturer, the unit was placed in commercial operation at its full capacity. The operation of this unit brought the rated capacity of the Shawnee power station to its full 1350MW. This makes it, so far as is known, the second largest steam-electric power station in the world. The T.V.A. Kingston power station, with 1440MW installed capacity, is believed to be the largest power station in the world.

Johnsonville.—Between June 7 and August 21, 1956, T.V.A. commenced the construction of four additional generating units, each of 135MW rated capacity. They will nearly double the size of the power station. The new units are scheduled to begin commercial operation over a period from September, 1958, to June, 1959. The present capacity in operation consists of six units of 112MW capacity. With the addition of the new units, the capacity of the power station will be raised from 675MW to 1215MW.

Gallatin.—The first two units of this power station, each of 225 MW rated capacity, were placed in operation during the fiscal year, although somewhat behind schedule because of late delivery of the turbo-generators. Other difficulties were encountered, including an electrical failure which damaged the stator of one unit so that it had to be rebuilt. The first of the two units went into commercial operation on November 8, 1956, and the second one on June 27, 1957. Construction of two additional units was started in August, 1956. The new units will be 10 per cent larger than the first two, with rated capacities of 247MW. With the two new units, which are scheduled for commercial operation in December, 1958, and September, 1959, the four-unit power station will have a total installed capacity of 945MW.

John Sevier.—Construction of a fourth 180MW capacity unit at this power station was undertaken in April, 1956. It was placed in commercial operation in October, 1957. The first three units of the power station were placed in operation during the previous fiscal year. The three units in operation generated 4580 million kWh during the year, using 1,662,000 tons of coal. The power station (Fig. 8) has proved to be one of the most efficient in the T.V.A. system.

Transmission.—367 miles of transmission line were completed during the year, making the number of miles of line in service 11,001. About 1622MVA of substation transformer capacity was added. The major transmission project during fiscal year 1957 was the double-circuit 161kV line between the Gallatin steam power plant and the primary substation at Rockwood, Tennessee ; the first circuit, 106 miles in length, was completed and placed in service in May, 1957. The 200MVA Rockwood primary substation was placed in operation earlier in the fiscal year, when it was connected to the Watts Bar–Oak Ridge transmission line. The second circuit of the Gallatin–Rockwood line, 114 miles long, is to be placed in operation this summer. The line will provide power to the upper Cumberland plateau and to a new ferro-manganese plant at Rockwood. A 54-mile, 161kV line was completed in February between the Widows Creek steam power station and Huntsville, Alabama.

Fig. 8—Exterior view of the completed John Sevier steam power station comprising four turbo-generators of 180MW capacity each

Construction Economies

Evidence during the year continued to confirm the wisdom and economy of the Authority's policy of carrying on its planning, design and construction activities largely with its own engineering and construction organisation. At times and for various reasons, T.V.A. has contracted parts of important construction jobs, such as highway relocations, bridge construction and tunnel work. These have provided a measure of comparison of costs and other factors for similar work done by the Authority's own organisation.

The Shawnee steam power plant, where the tenth and final generating unit has been placed in operation, provided some striking data on the comparative costs of contract and force account construction. The first four units of the station were started in 1951 on virtually an emergency schedule to provide electric power to a new Atomic Energy Commission plant at Paducah, Kentucky.

	Units 1–4 contract cost per unit	Units 5–10 force account cost per unit	Indicated savings per unit	Per cent savings	Indicated savings on 6 units
	Dollars	Dollars	Dollars		Dollars
Boiler	1,396,684	1,114,353	282,331	20·2	1,693,986
Turbo-generator	314,000	221,650	93,350	29·7	560,100
Condenser	76,390	40,126	36,264	47·5	217,584
Structural steelwork	241,800	187,200	54,600	22·6	327,600
Total savings	—	—	—	22·9	2,793,270

Not having equipment or manpower immediately available, T.V.A. awarded contracts for parts of the job—erection of boilers, turbo-generators, condensers and structural steelwork. With the subsequent expansion of the power station to include six additional generating units, the Authority assembled its own crews and equipment and undertook the same operations by force account. The table above summarises the results.

The actual costs of the seven major steam power stations constructed by T.V.A. since 1949 are expected to be below the official estimates by about 6 per cent. The average cost per kilowatt of capability for these seven power stations, including switchyards, is 133 dollars. Estimates submitted to Congress for all major hydro-electric and steam power station installations completed or scheduled for completion by June 30, 1957, totalled 1668 million dollars. The actual comparable costs were about 1628 million dollars, showing a saving of 40,000,000 dollars, or 2·4 per cent.

The average heat rate of about 9700 B.Th.U. per net kilowatt-hour generated in the seven large steam power stations ranks them high among the most thermally efficient power stations in the world. The design costs, including the preparation of detailed construction and procurement drawings and speci-fications for materials and equipment, have averaged 2 to 3 per cent of the construction costs on nearly 2000 million dollars' worth of varied engineering work.

This is lower than the usual consulting fees for engineering services. Moreover, the complete design service given construction forces, fabricators and manufacturers through detailed design drawings, information and advice helps to obtain the highest quality materials and workmanship consistent with economy. While this " turn-key " service adds to the cost of design, it has been demonstrated that the extra design effort results in savings in total project costs.

It has been possible to construct power stations at a relatively low cost per kilowatt of capability. At the Shawnee power station, the cost for the ten units was 144 dollars per kilowatt, while at the Kingston power station, which also is a large supplier of power to the A.E.C., the cost per kilowatt was 123 dollars. In comparison the eleven units in two power stations of the Ohio Valley Electric Corporation cost 156 dollars per kilowatt, and the cost at the Joppa power station of Electric Energy, Incorporated, across the Ohio River from the Shawnee power station, was 182 dollars per kilowatt, as reported by the U.S. Comptroller General in a report on A.E.C. contracts for electric power. All three of the private power stations were constructed mainly to serve the A.E.C.

Personal and Business

Appointments

MR. ARTHUR BOOTH has been appointed director and general manager of Landmaster, Ltd.

MR. J. F. GARDNER has been appointed representative for the northern areas of Refractory Mouldings and Castings, Ltd.

MR. G. M. WARREN has been appointed general sales manager of Aveling-Barford, Ltd., and Mr. D. H. Allam, assistant general sales manager.

MR. JOHN D. THORNLEY has been appointed northern England representative of the fluid power division of the Baldwin Instrument Company, Ltd.

MR. D. A. C. BENNETT, overseas sales manager of the Dunlop Rubber Company, Ltd., has been appointed to the local board at Fort Dunlop, Birmingham.

DR. W. H. GARRETT, director of Monsanto Chemicals, Ltd., has been elected president of the British Employers Confederation in succession to Sir Colin Anderson.

LAYCOCK ENGINEERING, Ltd., has announced that Mr. Dexter L. England and Mr. Arthur W. Fawke have been appointed assistant sales managers of the company's industrial division.

MR. EDWARD E. TOON has been appointed managing director of Weldall and Assembly, Ltd., in succession to Sir Graham Cunningham. Sir Graham remains chairman of the company.

THE CHAMBER OF SHIPPING of the United Kingdom announces that Mr. R. D. Ropner has been elected president in succession to Viscount Simon and that Sir Nicholas Cayzer had been appointed vice-president.

GEORGE ELLISON, Ltd., has announced the appointment of Mr. B. J. Hersey as technical engineer, responsible for the sales and consultative service for Ellison hydraulic valves in the south of England and South Wales.

MR. W. RODDIS has been appointed area representative of Kelvin and Hughes (Industrial), Ltd., for the East and West Ridings of Yorkshire, north Lincolnshire and north Derbyshire, in succession to Mr. J. Illingworth.

MR. D. N. GREEN has been appointed purchasing manager of the A.P.V. Company, Ltd. Mr. H. E. Woodall has retired from his post as joint purchasing manager, but remains with the company in the capacity of purchasing adviser.

EXPANDITE, Ltd., announces that Mr. R. J. Masterson (overseas division) has left to take up the appointment as manager, central African division. Mr. P. L. Critchell, technical advisory officer, has been appointed manager of the newly-formed sales development department.

THOMAS MERCER, Ltd., has announced the appointment of Mr. J. C. Helliar as sales manager of its air gauge division. Mr. D. G. Carter and Mr. F. M. Harvey have been appointed representatives. The company has also opened new premises in Old London Road, St. Albans, for the manufacture of standard and special air gauging units.

Business Announcements

MARTONAIR, Ltd., has opened a new branch office at 71, Carver Street, Sheffield, 1 (telephone, Sheffield 21641).

SEMICONDUCTORS, Ltd., states that its sales and administrative staff have moved from Ilford to its new factory at Cheney Manor, Swindon, Wilts (telephone, Swindon 6421/2).

THE UNITED STEEL COMPANIES, Ltd., has announced that it is to set up a central drawing office at 125–127, Victoria Street, London, S.W.1. Mr. R. M. W. Lowe has been appointed manager of the new drawing office.

LANG-LONDON-LTD., has announced that, following extensions to its premises, all office departments will be accommodated at 45, Hampstead Road, London N.W.1 (telephone, Euston 3744), as from Monday, March 24.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., states that with effect from Monday, March 24, the address of its Sheffield district office will be 9, Market Place, Sheffield, 1 (telephone, Sheffield 23114/7 and 27848).

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., states that it has grouped the sections engaged in test and inspection activities into a single department, to be known as the test department. Mr. H. J. H. Wassell has been appointed manager of the new department and Mr. J. K. Todd, A.M.I.E.E., has been appointed chief radar engineer.

GEORGE KENT, Ltd., states that the name of its Canadian subsidiary company has been changed from Kent-Norlantic, Ltd., to George Kent (Canada), Ltd. The address for the offices and plant, 389, Horner Avenue, Toronto, 14, remains unchanged.

THE THERMATIC HEATING COMPANY, Ltd., states that all its departments are now concentrated at Carlton Road, South Croydon, Surrey (telephone, Croydon 9258/9, 9250). The technical and sales offices at Red Lion Street have been closed.

DAVY AND UNITED ENGINEERING COMPANY, Ltd., states that all its Sheffield activities are now concentrated at Darnall Works, Sheffield, 9, and that it has disposed of Park Iron Works. Darnall Works thus becomes the head office of the company.

COURTAULDS, Ltd., has announced that an agreement has been concluded with Hobourn Aero Components, Ltd., whereby Hobourn Aero Components will acquire a substantial shareholding in the F.N.F. Machinery Manufacturing Company, Ltd.

THE PORT OF NEW YORK AUTHORITY has opened a London Trade Development office at Fountain House, 130, Fenchurch Street, London, E.C.3, to provide information of transport services and other facilities, including marine and land terminals and airports.

TWIFLEX COUPLINGS, Ltd., has announced the introduction of Twiflex disc brakes (incorporating Dunlop disc brake operating units) to its range of power transmission equipment. Mr. W. R. Dearden, A.M.I.Mech.E., has been appointed senior engineer of the industrial disc brake department.

FIRTH CLEVELAND STEEL STRIP, Ltd., states that the trade mark "Fircleve" has been accepted by the Registrar of Trade Marks as applicable to the range of cold rolled steel strip and flattened wire, and cold rolled hardened and tempered steel strip and flattened wire, produced and marketed by the company. The trade mark registration number is 770,885.

Contracts

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has been awarded a contract valued at approximately £1,500,000, covering the construction and equipping of the Gach Saran power system for the Iranian Oil Exploration and Producing Company. The scheme will comprise a 12MW power station, switchgear, transformers and transmission lines in the Gach Saran oilfield located some 2500ft above sea level in Southern Iran, whence oil will be piped to a new sea terminal at Kharg Island in the Persian Gulf. Sub-contractors for the associated civil engineering are Richard Costain, Ltd., and for the transmission lines and cable work British Insulated Callender's Construction Company, Ltd. The consulting engineers are Ewbank and Partners, Ltd. The complete system is to be commissioned in May, 1960. Power station generating plant will consist of three Metropolitan-Vickers "L.51 C" gas turbine-generators nominally rated at 4000kW; the maximum rating of each unit will be 5500kW.

Miscellanea

OIL EQUIPMENT.—We are informed by the Council of British Manufacturers of Petroleum Equipment that the orders for oil equipment and materials received by British firms in 1957 amounted in value to £134,050,000, compared with the 1956 total of £153,730,000.

AIRCRAFT POWER PLANT.—In announcing that two "Gyron Junior" turbo-jets will power the Blackburn "NA-39" naval strike aircraft, the de Havilland Engine Company, Ltd., draws attention to the fact that the first version, of 7000 lb thrust, has a manifold providing bleed air for such purposes as flap blowing.

SHIPBUILDING CONFERENCE.—According to Shipbuilding Conference statistics, 51 ships, of 180,000 gross tons, were ordered in the fourth quarter of 1957, and brought the orders for 1957 up to 258 ships of 1,679,000 gross tons. At the end of the year the total order book stood at 812 ships of 6,828,000 tons, estimated in value at £1000 million, of which 20 per cent were for foreign account and 54 per cent were oil tankers.

MOISTURE-RESISTANT WALLBOARD.—Bakelite, Ltd., has introduced a new moisture-resistant Warerite-faced hardboard for use on vertical surfaces and ceilings. Known as Warerite Wallboard, it consists of a high density fibre hardboard core surfaced on both sides with melamine resin impregnated papers moulded under heat and pressure. The overall thickness is ¼in and the material can be cut to shape by standard tools.

LIGHTWEIGHT CONTAINERS.—The range of containers produced by Light Alloy Construction, Ltd., Mowden Hall, Darlington, now includes a "Tracon" one-piece folding light alloy container which is available in four sizes of 2, 4½, 9 and 16½ cubic feet capacity respectively. The cases are built of a toughened aluminium alloy, produced by the British Aluminium Company, Ltd., and fitted with hardened steel corners and can be folded to one-fifth of their original size.

CATHODIC PROTECTION OF COUPLED STEEL PIPELINES.—When cathodic protection is applied to a pipeline it is essential for the line to be electrically continuous; if Viking Johnson couplings, or similar electrically insulating couplings are used, each joint must be bonded to give continuity. We are informed that Metal and Pipeline Endurance, Ltd., Artillery Mansions, Victoria Street, London, S.W.1, now manufactures a bond to minimise current attenuation, particularly in the case of impressed current schemes. The "Mapelbond," as it is called, is a 1in by ¼in copper bar, with tails for welding to the pipe on each side of the joint, the centre portion being bonded into the sleeve, using either a weld or a special connection in the top plug of the sleeve. The bar is also fitted in slots in the rings of the joint and the slots then peened over.

HIGH-SPEED FLIGHT.—The second of a triology of films dealing with high-speed flight which have been sponsored by The Shell Petroleum Company, Ltd., has been completed recently. The first, entitled "Approaching the Speed of Sound," was shown about a year ago and while the third, "Supersonic Flight," was in course of production. Film No. 2 is entitled "Transonic Flight" and deals with the problems encountered within the transonic speed range, which extends from the aircraft's critical Mach number through Mach 1 to about Mach 3. The colour schlieren method of photography has been used to demonstrate the flow of air, by changes in density that occur in this speed range, and the film demonstrates the formation of shock waves, flow separation, wave drag and the design principle known as the "Area Rule."

INSTITUTE OF METALS.—The "golden jubilee" spring meeting of the Institute of Metals is to be held in London from Monday to Friday, April 28 to May 2. The headquarters for the meeting will be at Church House, Great Smith Street, Westminster, S.W.1, and the sessions for the discussion of technical papers will be held there on Tuesday, Wednesday and Thursday. The May lecture is to be given on Tuesday, April 29, at 3 p.m., by Professor A. G. Quarrell; the lecture is entitled "Fifty Years of Metallurgical Science." Events of special importance in the programme are the golden jubilee lecture to be delivered by Professor R. S. Hutton at the Royal Institution, Albemarle Street, W.1, on Monday, April 28, at 8.15 p.m.; a reception at the Fishmongers' Hall on Tuesday, April 29 at 7.30 p.m., and the golden jubilee banquet at Grosvenor House, Park Lane, W.1, on Thursday, May 1. The Lord President of the Council, Lord Hailsham, P.C., Q.C., will be the principal guest at the banquet.

GREAT EASTERN MODERNISATION.—One of the track works being undertaken on British Railways in preparation for the Liverpool Street–Enfield, Hertford (East) and Bishops Stortford electrification is in the Rectory Road–Stoke Newington area; it includes lowering of the track, reballasting and drainage over a distance of approximately three-quarters of a mile. A new track drainage system is being installed during week-ends when possession of both tracks can be obtained. A trench is excavated by a mechanical digger operating on timbers laid across the 6ft space between both lines. The use of "Armco" metal drainage pipes, prefabricated into 80ft sections, is being tried, it is believed, for the first time in British railway engineering. The "Armco" pipe is in 20ft sections of galvanised steel, corrugated for strength and perforated to allow water to get in; 20ft sections connected together as required in lengths of up to 100ft are placed as one unit into the trench on concrete-filled bags placed at intervals and set to level, the rigidity of the pipe ensuring continuity of line and level. Concrete is then rammed underneath to form a continuous support and the trench is back-filled with a graded gravel filter. The whole sequence of operations is economical in manpower. A 15in lowering of the track through Stoke Newington tunnel is necessary to accommodate the overhead electric wires. Excavation will expose the clay formation underneath the existing ballast and to ensure stability a blanket of sand is to be placed between the clay and the new ballast. All the work is being undertaken by railway labour under the direction of Mr. A. K. Terris, M.I.C.E., chief civil engineer, Eastern Region, British Railways.

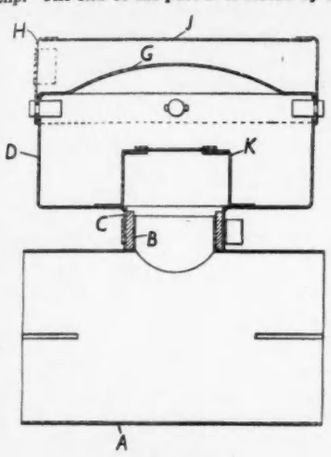
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

VIBRATION DAMPERS

790,519. November 9, 1955.—THE INHIBITION OF VIBRATION IN FLOWING GAS, S. Smith and Sons (England), Ltd., Cricklewood Works, Cricklewood, London, N.W.2. (*Inventor: Donald William Copley.*)

It is an object of the invention to provide means to damp unwanted vibrations in a stream of gas flowing through a pipe which do not permit the escape of gas from the pipe and do not interfere with the free flow of gas through the pipe. The drawing shows a sectional view of a device suitable for use in a combustion heater installation in a passenger coach. The combustion heater itself is as disclosed in the Specification No. 715,835. The exhaust gases from it pass through a main exhaust pipe, in a normal installation some 3in in diameter, to the atmosphere at the rear of the coach. A section of the exhaust pipe adjacent to the heater, indicated at *A*, is formed with a short outwardly-extending open stub piece *B*, conveniently about 1½in in diameter. This fits inside a further stub pipe *C* extending from the base of a drum-shaped metal part *D*, about 5in in diameter and 2in deep. The space between the pipes *B* and *C* is filled with an asbestos packing and the pipes held by a clip. The end of the part *D* is closed by a loose



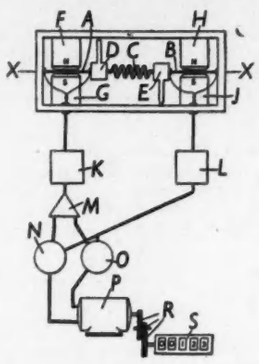
No. 790,519

diaphragm *G* of suitable flexible material, for example, rubber, whose edge fits over the edge of the drum-shaped member and is retained in position by a cap *H* having a base portion *J* of steel wire gauze, which also serves to protect the diaphragm from mechanical damage. A further cap-shaped member *K* is carried on the base of the part *D* extending in the opposite direction from the stub pipe *C* and covering the inner end of the stub pipe. The base of the member *K* is also of wire gauze. This therefore permits the free flow of exhaust gases through the stub pipe *C* but prevents the direct impingement of the exhaust gases on the diaphragm *G*. The manner in which the chamber enclosed by drum and diaphragm inhibits the occurrence of vibrations in the exhaust gas stream passing through the pipe is not altogether clear, but it appears that any tendency to vibration results in oscillatory flow of exhaust gases between the chamber and the exhaust pipe, which involves the abstraction of energy from, and hence the damping of, vibration. The size of the chamber does not appear to be critical, provided that it is sufficiently large, but it does appear to be important that it should be situated fairly close to, e.g. within 6in to 9in of, the heater end of the exhaust pipe.—*February* 12, 1958.

SCIENTIFIC INSTRUMENTS

789,611. May 3, 1955.—ACCELEROMETERS, A. V. Roe and Co., Ltd., Greengate, Middleton, Manchester. (*Inventor: Kenneth Victor Diprose.*)

The invention relates to accelerometers, giving an output in a convenient form for operating accurate integrating means. As the drawing shows two vibrating wires *A* and *B* are arranged to extend in the direction of the axis *X–X* along which accelerations are to be measured. The wires are anchored to the instrument housing at their outer ends, and at their inner ends are connected together by a spring *C* at the ends of which are mounted weights *D* and *E* each having arms projecting laterally to guide it in the housing without restraining axial movement. The wire *A* extends between magnet poles *G* and *F* and the wire *B* extends between magnet poles *H* and *J*. The wires *A* and *B* are connected respectively to electronic oscillators *K* and *L* whereby they are kept in oscillation at their natural frequencies as determined by the tension in the spring *C* as long as the instrument is not being subjected to any acceleration. The output of the oscillator *K* is passed to



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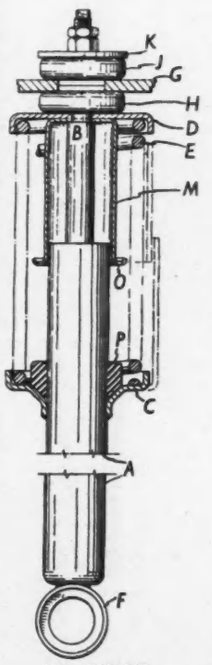
a phase-splitter *M* which produces two signals in quadrature. Each of these signals is mixed with the output of the oscillator *L* in the modulator *N* or *O*, the outputs from the modulators being two signals in quadrature, each having a frequency equal to the difference between the frequencies of the oscillators *K* and *L*. When the instrument is subjected to acceleration along the axis *X–X* the freely movable weights *D* and *E* are displaced, with the result that the tensions in the wires *A* and *B* become unequal, and the frequency of oscillation of one wire increases while that of the other decreases. There is a resulting difference between the frequencies of the oscillators *K* and *L* which appears in the outputs from the modulators *N* and *O*. The output signals from the modulators are used to drive a two-phase synchronous motor *P* the speed of which is therefore proportional to the acceleration. A counter *S*, driven by the motor through a gear train *R*, then reads the integral of the acceleration, that is the velocity of translation of the instrument.—*January* 22, 1958.

SHOCK ABSORBERS

790,647. May 11, 1955.—TELESCOPIC HYDRAULIC SHOCK ABSORBERS, Armstrong Patents Company, Ltd., Eastgate, Beverley, Yorkshire. (*Inventor: Leslie Gaillard Freeman.*)

An object of the inventon is to provide an improved cushioning arrangement in telescopic hydraulic shock absorbers. As will be seen in the drawing, a piston, slidable within a cylinder *A*, is mounted upon a piston rod *B*. The cylinder and piston rod carry spring seating members *C* and *D* respectively, with a coil spring *E* between. The cylinder is provided with a mounting ring *F* and the piston rod passes through a vehicle framework *G*. A rubber ring *H* is disposed on the piston rod between the seating and the framework and a rubber ring *J* on the piston rod between the framework *G* and a washer *K* on the piston rod. A shroud *M* on the piston rod is flanged at *O* to engage with a rubber cushioning ring *P*, bonded to the spring seating member *C*. A modification is also shown in the specification. The cushioning arrangement embodied in the telescopic hydraulic shock absorber according to the invention has the advantage that at least part of the impact load is transferred through the dust covers and not entirely through the inside components of the shock absorber. Consequently, the impact load is more uniformly distributed throughout the shock absorber components than in the conventional arrangement. The provision of the shroud also protects the piston rod against foreign matter.—*February* 12, 1958.

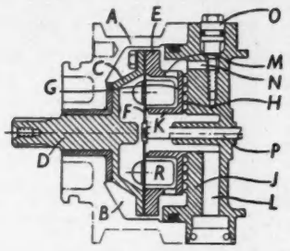


No. 790,647

PUMPS

790,653. June 28, 1955.—CENTRIFUGAL PUMPS, Blackburn and General Aircraft, Ltd., Brough, East Yorkshire. (*Inventor: Francis Robert Bell.*)

The invention relates to centrifugal pumps and is particularly concerned with pumps for supplying fuel to engines such as gas turbines. Its object is to provide a simple, efficient design incorporating flow regulating means. Referring to the drawing, the pump comprises a casing *A* having a hollow chamber *B* in which is a rotor *C* fast with a driving shaft *D*. The rotor comprises a main part *C* and associated part *E* which are joined at their respective peripheries to clamp there between the margin of a flexible diaphragm *F*. The rotor part *E* has a portion *G* acting in conjunction with a sealing labyrinth *H* in the back plate *J* and a portion *K* which extends round to abut the diaphragm *F* in its normal unstressed



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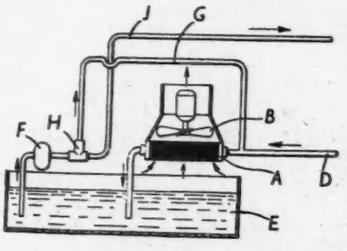
position. Liquid enters through the back plate *J* via a bore *L* to enter the annulus formed by the portion *K* and passes to the entry orifice formed by the extremity of that part and normally closed by the diaphragm *F*. Liquid entering between the diaphragm and the margin of the portion *K* is discharged through orifices *M* in the part *E* into the chamber *B* to flow through the bore *N* opening into the pump discharge in which is situated a screw plug valve *O* designed to regulate the maximum liquid output of the pump. A control member *P* extends through the back plate *J* and is made fast to the centre of the diaphragm *F*; this member *P* is under control of a governor or regulator and by its axial displacement moves the diaphragm *F* away from the extremity of the portion *K* to open the liquid entry. The diaphragm *F* is provided with a number of mass members *R* which, due to their rotation with the diaphragm and rotor *C*, force round the liquid entering the pump to discharge it at a pressure at the outlet. The masses are also subject to centrifugal force which causes them to flex the diaphragm to tend to cause it to close the liquid entry so that the masses act against the opening effect of the control member *P*. Alternative designs are also shown in the specification. —*February* 12, 1958.

MACHINE TOOLS

790,430. March 1, 1955.—HYDRAULICALLY OPERATED MACHINES, The Newall Engineering Company, Ltd., Old Fletton, Peterborough, Northamptonshire, and Stanley William Hoare, 120, Oundle Road, Orton, Longueville, Huntingdonshire.

The invention relates to hydraulically-operated machines, particularly machine tools. It is well known that during the operation of such machines, the working fluid heats up as it circulates, which creates a number of problems. It provides an air-cooled heat exchanger in the circuit through which all the fluid pumped passes. As shown in the accompanying diagrammatic drawing, the working fluid is passed through an air-cooled radiator *A* of the type



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generally employed on motor vehicles, air at ambient temperature being forced through the air passages of the radiator by means of a fan *B*. The radiator is situated in the exhaust or return line *D* conveying the fluid from the machine back to the sump or reservoir *E*, from which the supply for the pump *F* is drawn. A pump delivering working fluid to a hydraulic machine is normally continuously running, and the fluid delivered in excess of the machine's requirement is by-passed back to the reservoir through a relief or off-loading valve. In the arrangement, a by-pass *G*, from an off-loading valve *H* in the delivery line *J*, enters the exhaust line *D* upstream of the radiator *A*, so that the whole of the fluid circulated by the pump passes through the radiator.—*February* 12, 1958.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, March 14.—STOKE AND CREWE BRANCH: Royal Hotel, Crewe, "Storage Batteries," D. L. Jayne, 7.30 p.m.

Sat., March 15.—OXFORD, READING AND DISTRICTS BRANCH: Collier Lecture Room, Regents' Park College, Pusey Street, Oxford, "The Industrial Uses of Radio-Active Isotopes," 7 p.m.

Tues., March 18.—LONDON NATIONAL LECTURE: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Industrial Closed-Circuit Television," R. E. Blythe, 6.30 p.m.

Thurs., March 20.—NORTH WEST LONDON BRANCH: Evening visit to the Mount Pleasant Parcels Office.

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., March 18.—LONDON SECTION: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Discussion, "Recommended Method of Expressing Electronic Measuring Instrument Characteristics: I:—A.M. or F.M. Signal Generators," 6.30 p.m.

Fri., March 21.—MERSEYSIDE SECTION: Technical College, Birkenhead, "Radio Exploration of the Galaxy," J. E. Baldwin, 7 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., March 19.—NORTHERN REGION: Grand Hotel, Sheffield, 1, Brains Trust on "Space Heating and Insulation," 11 a.m.; Two papers on "Boiler Inefficiency," 2.15 p.m.

DIESEL ENGINEERS AND USERS ASSOCIATION

Thurs., March 20.—Caxton Hall, Westminster, London, S.W.1, "Governing of Diesel Engines," R. A. Fuller, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., March 17.—BATH AND BRISTOL CENTRE: Royal Hotel, Bristol, "Decorative Lighting—A Designer's Approach," D. W. Durrant, 7 p.m.

Tues., March 18.—GLOUCESTER AND CHELTENHAM CENTRE: Fleece Hotel, Westgate Street, Gloucester, "The New Approach to Interior Lighting Design," J. M. Waldram, 6.30 p.m. ★LIVERPOOL CENTRE: Committee Rooms, Liverpool Passenger Transport Office, 24, Hatton Garden, Liverpool, 3, "Light as an Effective Aid to Architecture," R. H. Ruff, R. U. Mills and H. E. Bellchambers, 6 p.m.

Wed., March 19.—TEES-SIDE GROUP: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "The Lighting Laboratory," G. Mainwaring, 6.30 p.m.

Thurs., March 20.—MANCHESTER CENTRE: Demonstration Theatre, N.W. Electricity Board, Town Hall, Manchester, 2, "An Architect's Views on Lighting," J. R. Sheridan, 6 p.m.

Mon., March 24.—LEEDS CENTRE: Lighting Service Bureau, 24, Aire Street, Leeds, 1, "Street Lighting in Leeds and Remote Control Systems," K. J. Goddard and T. C. Holdsworth, 6.15 p.m. ★LEICESTER CENTRE: Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, "Television Studio Lighting Equipment," K. R. Ackerman, 7 p.m.

INCORPORATED PLANT ENGINEERS

Wed., March 19.—EAST MIDLANDS BRANCH: Sherwood Room, County Hotel, Theatre Square, Nottingham, Annual General Meeting, 7 p.m. ★KENT BRANCH: King's Head Hotel, High Street, Rochester, "High-Pressure Steam Generation," O. S. Denham, 7 p.m. ★LEICESTER BRANCH: Bell Hotel, Leicester, Annual General Meeting, 7 p.m.

Thurs., March 20.—BLACKBURN BRANCH: Golden Lion Hotel, Blackburn, Annual General Meeting, 7.30 p.m. ★LONDON BRANCH: College of Preceptors, Bloomsbury Square, London, W.C.1, "The Construction of a Nuclear Power Station," 7 p.m. ★PETERBOROUGH BRANCH: White Lion Hotel, Church Street, Peterborough, Annual General Meeting, 7.30 p.m.

Fri., March 21.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, Annual General Meeting, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., March 18.—EAST ANGLIAN SECTION: Lecture Hall, Public Library, Ipswich, "Experiences of Forty Years In and Around Foundries," W. Hardy, 7.30 p.m. ★SLOUGH SECTION: Lecture Theatre, High Duty Alloys, Ltd., Slough, Annual General Meeting, "Non-Destructive Testing of Castings," S. L. Fry, 7.30 p.m.

INSTITUTE OF FUEL

Wed., March 19.—YORKSHIRE SECTION: Hotel Metropole, Leeds, "Conversion of Coal-Fired Plant to Oil Fuel," T. Marsden, 2.30 p.m.

Thurs., March 20.—EAST MIDLAND SECTION: Loughborough College, Loughborough, "Small Pressurized Water Atomic Power Plants," H. S. Prosser, 7.15 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., March 17.—STUDENT LECTURE: Memorial Building, 76, Mark Lane, London, E.C.3, "Safety at Sea," S. Hogg, 6.30 p.m. ★WEST OF ENGLAND SECTION: Smith's Assembly Rooms, Bath, "Marine Gas Turbine," B. G. Markham, 7.30 p.m.

Tues., March 18.—EDUCATIONAL GROUP: Memorial Building, 76, Mark Lane, London, E.C.3, Annual General Meeting; Discussion, "Should Marine Engineers Have Pre-Seagoing Operational Instruction," opened by D. G. Alcock, 5.30 p.m.

Wed., March 19.—SOUTHERN BRANCH: Southampton Technical College, St. Mary Street, Southampton, Joint Meeting with Southern Branch of Institution of Naval Architects, Annual General Meeting; "The Harland and Wolff Pressure Charged Two-Stroke Single-Acting Diesel Engine," C. C. Pounder, 7.30 p.m.

Thurs., March 20.—KINGSTON UPON HULL AND EAST MIDLANDS SECTION: Hotel Metropole, Leeds, "Nodal Dampers," G. Hallewell, 7.30 p.m. ★JUNIOR LECTURE: Woolwich Polytechnic, London, S.E.18, "The Launching of Ships," R. S. Hogg, 7 p.m.

INSTITUTE OF METALS

Tues., March 18.—SOUTH WALES LOCAL SECTION: Department of Metallurgy, University College, Singleton Park, Swansea, Annual General Meeting, 6.30 p.m.

Wed., March 19.—POWDER METALLURGY JOINT GROUP: Church House, Great Smith Street, London, S.W.1, Informal Discussion, "Developments in the Practice of Compacting and Sintering," 10 a.m.

Thurs., March 20.—BIRMINGHAM LOCAL SECTION: College of Technology, Gosta Green, Birmingham, Annual General Meeting, and Chairman's Address, 6.30 p.m.

INSTITUTE OF NAVIGATION

Fri., March 21.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Effective Utilization of Airspace," E. J. Dickie, 5.15 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, March 14.—WESTERN CENTRE: Duke of Cornwall Hotel, Millbay Road, Plymouth, "The Construction and Operation of the Distributor Pump," 7 p.m. ★SOUTH WALES CENTRE: South Wales Institute of Engineers, Park Place, Cardiff, Open Forum, 7 p.m.

Mon., March 17.—SCOTTISH CENTRE: North British Hotel, Edinburgh, "Some Considerations Affecting the Selection and Use of Fuels and Lubricants for Road Transport," C. T. Tresidder, 7.30 p.m.

Tues., March 18.—NORTH EASTERN CENTRE: Liverpool Architectural Society's Rooms, Bluecoat Chambers, School Lane, Liverpool, 1, "Some Considerations Affecting the Selection and Use of Fuels and Lubricants for Road Transport," C. T. Tresidder, 7.30 p.m.

Thurs., March 20.—MET. AREA: Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "Road Transport Forum," 6.30 p.m. ★YORKSHIRE CENTRE: Great Northern Hotel, Wellington Street, Leeds, 1, "The Commer T.S.3 Two-Stroke Diesel Engine," E. W. Coy, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., March 18.—NORTH WESTERN BRANCH: Reynolds Hall, College of Science and Technology, Manchester, "Heat Transfer in Relation to Nuclear Engineering," W. B. Hall, 7 p.m.

Wed., March 19.—SOUTH WALES GRADUATES AND STUDENTS' CENTRE: University College, Cardiff, "Gas/Solid Reactions in Fluidised Beds," E. S. Sellers, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., March 18.—Great George Street, Westminster, London, S.W.1, James Forrest Lecture, Sir John Cockcroft, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, March 14.—NORTH EASTERN GRADUATE AND STUDENT SECTION: Grey Hall, King's College, Newcastle upon Tyne, "Electricity in Western Australia," R. G. Harvey, 6.30 p.m. ★NORTH SCOTLAND SUB-CENTRE: Robert Gordon's Technical College, Aberdeen, "Electrical Floor Warming," J. W. Moule and W. M. Stevenson, 7.30 p.m.

Sat., March 15.—NORTH EASTERN GRADUATE AND STUDENT SECTION: Visit to I.C.I., Ltd., Wilton, 8.45 a.m. ★SOUTH MIDLAND GRADUATE AND STUDENT SECTION: Visit to Courtaulds, Ltd., Coventry, 9.30 a.m.

Mon., March 17.—EAST ANGLIAN SUB-CENTRE: Assembly House, Norwich, "The Human Operator in Closed-Loop Control Systems," K. A. Hayes, 7.30 p.m. ★MERSEY AND NORTH WALES CENTRE: Town Hall, Chester, Joint Meeting with North Western Centre, "Recent Uses of Ultrasonics in Investigating the Characteristics of Materials," J. Lamb, 6.30 p.m. ★NORTH EASTERN RADIO AND MEASUREMENTS GROUP: King's College, Newcastle upon Tyne, "Some Transistor Input Stages for High-Gain D.C. Amplifiers," and "A Transistor High-Gain Chopper-Type D.C. Amplifier," G. B. B. Chaplin and A. R. Owens, 6.15 p.m.

Tues., March 18.—LONDON GRADUATE AND STUDENT SECTION: Public Library, Chelmsford, Films, 7 p.m. ★NORTH MIDLAND CENTRE: Technical College, Bradford, Joint Meeting with Utilization Group, "Circuit Breaking and Power System Problems," C. H. W. Lackey and A. T. Crawford, 7 p.m. ★NORTH WESTERN UTILIZATION GROUP: Engineers' Club, Albert Square, Manchester, "The Use of Steel Tank Mercury-Arc Inverters for Generating Medium Frequencies for Induction Heating," D. L. Smart and J. J. L. Weaver, 6.15 p.m. ★SOUTH EAST SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "The B.B.C. Sound Broadcasting Service on Very-High Frequencies," E. W. Hayes and H. Page, 7 p.m. ★SOUTH WEST SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "The Potentialities of Railway Electrification at the Standard Frequency," E. L. E. Wheatcroft and H. H. C. Barton, 7 p.m.

Wed., March 19.—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, "Efficiency and Reciprocity in Pulse-Amplitude Modulation: Part 1—Principles," K. W. Cattermole; "Part II—Testing and Applications," J. C. Price and "Transistor Pulse Generators for Time-Division Multiplex," K. W. Cattermole, 5.30 p.m. ★LONDON GRADUATE AND STUDENT SECTION: Visit to University of London Observatory, Mill Hill Park, London, N.W.7, 6 p.m. ★NORTH WESTERN RADIO AND TELECOMMUNICATION GROUP: College of Science and Technology, Manchester, "Domestic High-Fidelity Reproduction," J. Moir, 6.45 p.m. ★NORTH STAFFORDSHIRE SUB-CENTRE: Technical College, Stafford, Joint Meeting with Graduate and Student Section; Three Short Papers, 7 p.m. ★SOUTHERN CENTRE: Technical College, Brighton, "British Columbia–Vancouver Island 138kV Submarine Power Cable," T. Ingledow, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson, 6.30 p.m.

Thurs., March 20.—ORDINARY MEETING: Savoy Place, London, W.C.2, "Storage and Manipulation of Information in the Brain," R. L. Beurle, 5.30 p.m. ★LONDON GRADUATE AND STUDENT SECTION: Visit to B.P. Refinery (Kent), Ltd., Isle of Grain, 9 a.m. ★SOUTH WESTERN SUB-CENTRE: South Western Electricity Board Showrooms, New George Street, Plymouth, "Cathodic Protection," L. B. Hobgen, K. A. Spencer and P. W. Heselgrave, 3 p.m.

Mon., March 24.—NORTH EASTERN CENTRE: Neville Hall, Newcastle upon Tyne, "The Design of a 330kV Transmission System for Rhodesia," F. C. Winfield, T. W. Wilcox and G. Lyon, 6.15 p.m. ★SOUTH MIDLAND RADIO AND MEASUREMENTS GROUP: James Watt Memorial Institute, Great Charles Street, Birmingham, "Colour Television," D. A. Maurice, 6 p.m. ★WESTERN UTILIZATION GROUP: Technical College, Bath, "Brushless Variable-Speed Induction Motors," F. C. Williams and E. R. Laithwaite, 6 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., March 19.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Annual General Meeting, "Fuels and Injection Equipment for Traction Diesel Engines," H. A. Gill and J. M. Smith, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, March 14.—1, Birdcage Walk, Westminster, London, S.W.1, Technical Film Show, 6 p.m.

Sat., March 15.—LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, "High-Speed Engines," E. S. Moult, 11 a.m.

Mon., March 17.—DERBY A.D. CENTRE: Midland Hotel, Derby, "High Compression Ratios for Petrol Engines," C. L. Goodacre, 7.15 p.m. ★SCOTTISH A.D. CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Air Suspension for Road Vehicles," J. H. Sainsbury, 7.30 p.m. ★MIDLAND GRADUATES' SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Water Turbines," G. Watt and A. M. Brown, 6.45 p.m.

Tues., March 18.—SOUTH WALES BRANCH: King's Head Hotel, Newport, Mon, "Hydrokinetic Fluid Drives," J. G. Giles, 6 p.m. ★NORTH WESTERN A.D. CENTRE: Engineers' Club, Manchester, "Some Important Problems Concerning the Small Utility Car," D. Giacosa, to be read by J. H. Pitchford, 7.15 p.m. ★LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, "Some Mechanical Engineering Aspects of Investigations on Road Surface Characteristics and Skidding," K. H. F. Cardew, 6.30 p.m.

Wed., March 19.—EAST MIDLANDS BRANCH: Technical College, Lincoln, "The Design and Development of a Range of Diesel Engine Turbochargers," C. L. G. Worn, 7.15 p.m. ★YORKSHIRE GRADUATES' SECTION: Visit to Yorkshire Copper Works, Leeds, 7 p.m.

Thurs., March 20.—LUBRICATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion, "How to Bridge the Gap Between Theory and Practice in Lubrication," 6 p.m. ★MIDLAND BRANCH: James Watt Memorial Institute, Birmingham, "The Economics of Plant Renewal and Replacement," C. W. Griffiths, 6 p.m. ★YORKSHIRE BRANCH: Technical College, Halifax, "Problems of Space Flight," J. Humphries, 7 p.m. ★COVENTRY A.D. GRADUATES' SECTION: Wine Lodge, Burges, Coventry, Annual General Meeting; "Gas Turbines," A. E. Hordley, and "Heat Exchangers," E. R. Neale, 7.30 p.m. ★EAST MIDLANDS GRADUATES' SECTION: Gas Showrooms, New Road, Peterborough, "Journal Bearings," A. Lichtarowicz, 7.15 p.m. ★YORKSHIRE GRADUATES' SECTION: Hotel Metropole, Leeds, "Roof Supports in Coal Mines," S. G. Harris, 6.30 p.m.

Fri., March 21.—ORDINARY MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, "Failure of a 60MW Steam Turbo-Generator at Uskmouth Power Station," A. L. G. Lindley and F. H. S. Brown, 6 p.m. ★BARROW-IN-FURNESS PANEL: Danson's Café, St. George's Terrace, Millom, "Pressurised Gas Systems for Reactors," G. Brown, 7.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., March 20.—Geological Society of London, Burlington House, Piccadilly, London, W.1, "Betterments in the Quality of Refined Lead," J. S. Jacobi and B. H. Wadia, 5 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Wed., March 19.—SOUTHERN JOINT BRANCH: Technical College, Southampton, with the Institute of Marine Engineers, Annual General Meeting; "The Harland and Wolff Pressure Charged Two-Stroke Single-Acting Engine," C. C. Pounder, 7.15 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, March 14.—IPSWICH AND COLCHESTER SECTION: Davey Paxman and Co., Ltd., Colchester, "Work Study," R. S. Warne, Annual General Meeting, 7 p.m. ★SWANSEA SECTION: Central Library, Alexandra Road, Swansea, "Training for Industry," R. B. Southall, 7.30 p.m.

Mon., March 17.—SHEFFIELD GRADUATE SECTION: Royal Victoria Hotel, Sheffield, Annual General Meeting; Films, 6.30 p.m. ★STOKE-ON-TRENT SECTION: Grand Hotel, Hanley, Stoke-on-Trent, Annual General Meeting, "Powder Metallurgy," P. R. Marshall, 7 p.m.

Tues., March 18.—PETERBOROUGH SECTION: Conference Room, Peterscourt, Peterborough, Annual General Meeting; Films, 7.30 p.m. ★TEES-SIDE SECTION: College of Further Education, Cleveland Avenue, Darlington, Annual General Meeting; Films, 7 p.m. ★OXFORD SECTION: Town Hall, Oxford, Annual General Meeting, 7.30 p.m.

Wed., March 19.—NORWICH SECTION: Assembly House, Sexton Room, Theatre Street, Norwich, Annual General Meeting; "Automation of Copy Turning and Its Development," 7 p.m. ★BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Replacement of Metal by Laminated Plastics," G. C. Hulbert, and "The Purpose and Use of Plastic Tooling in Industry," P. G. Pentz, 7 p.m. ★WOLVERHAMPTON GRADUATE SECTION: Wolverhampton and Staffs College of Technology, Wulfruna Street, Wolverhampton, Annual General Meeting; "Lock Design and Manufacture," C. G. Smith, 7 p.m. ★MANCHESTER GRADUATE SECTION: Reynolds Hall, Room C.3, College of Science and Technology, Sackville Street, Manchester, Annual General Meeting; Films, 6.45 p.m.

Thurs., March 20.—NORTHERN IRELAND SECTION: Kensington Hotel, Belfast, Annual General Meeting, 7.30 p.m. ★LONDON SECTION: Royal Empire Society, Northumberland Avenue, Strand, London, W.C.2, Annual General Meeting, and "Incentive for Indirect Workers," F. Locke, 7 p.m. ★SOUTHAMPTON SECTION: Polygon Hotel, Southampton, "Piston Rings and Liners," Mr. Bowler, 7.15 p.m.

INSTITUTION OF RUBBER INDUSTRY

Fri., March 21.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Joint Meeting with Plastics Institute, "The Impact of Atomic Energy on Rubber and Plastics," R. Roberts, and "The Application of Rubber and Plastics in the Atomic Energy Field," 6.45 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Wed., March 19.—WALES AND MONMOUTHSHIRE BRANCH: Mackworth Hotel, Swansea, "Some Structures Involving Unusual Design Problems," C. E. Saunders, 6.30 p.m. ★YORKSHIRE BRANCH: Electricity Building, Hull, "Plymouth Breakwater Review," T. W. Riley, 6.15 p.m.

Thurs., March 20.—LANCASHIRE AND CHESHIRE BRANCH: Liverpool Engineering Society, 24, Dale Street, Liverpool, "High-Tensile Steel Bolts," E. M. Lewis, 6.45 p.m.

INSTITUTION OF WORKS MANAGERS

Thurs., March 20.—DONCASTER BRANCH: Earl of Doncaster Hotel, Doncaster, "Training and Development for Works Management," P. P. Shrubsole, 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, March 14.—ORDINARY MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Available Energy," R. D. Gifford, 7 p.m.

Fri., March 21.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Films, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., March 21.—Engineers' Club, Albert Square, Manchester, 2, "The Manchester University Radio Telescope," H. C. Husband, 6.45 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., March 21.—Lecture Theatre, Mining Institute, Newcastle upon Tyne, "Velocity Measurements in Close Proximity to a Ship's Hull," R. S. Cutland, 6.15 p.m.

ROYAL INSTITUTION

To-day, March 14.—21, Albemarle Street, London, W.1, "Artificial Satellites," H. S. W. Massey, 9 p.m.

ROYAL SOCIETY

Thurs., March 20.—Burlington House, Piccadilly, London, W.1, "Atomic Energy Authority Industrial Group Research Organization (Dounreay Reactor)," L. Rotherham, 4.30 p.m.

ROYAL SOCIETY OF ARTS

Wed., March 19.—John Adam Street, Adelphi, London, W.C.2, "Industrial Power of the Future," Sir Christopher Hinton, 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Wed., March 19.—BIRMINGHAM GROUP: Main Hall, Advanced College of Technology, Suffolk Street, Birmingham, "Comparison of Industrial Efficiency," L. H. C. Tippett and J. C. Pritchard, 6.30 p.m. ★ORDINARY MEETING: London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, "Industrial Production and Steel Consumption," Sir Robert Shone and H. R. Fisher, 5.15 p.m.

Thurs., March 20.—BRISTOL GROUP: Library Room, The University, of Bristol, Bristol, 8, "The Planning of Experiments," D. R. Cox, 5.45 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Tues., March 18.—B.I.S.R.A., Hoyle Street, Sheffield, "Trends in Basic Refractories," H. Parnham, 7 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Thurs., March 20.—14, Belgrave Square, London, S.W.1, "Some Factors Influencing the Behaviour of Bitumen Road Surfacings," G. M. Dormon and A. W. Jarman, 6 p.m.

SOCIETY FOR WATER TREATMENT AND EXAMINATION

To-day, March 14.—Library, Royal Society of Health, 90, Buckingham Palace Road, London, S.W.1, Annual General Meeting, 9.30 a.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., March 20.—Institute Buildings, Park Place, Cardiff, "The Metallurgy of Haulage and Lifting Gear," R. Jeffrey and B. J. Nield, 6 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, March 14.—39, Elmbank Crescent, Glasgow, C.2, "Use and Application of the 'Quantovac,'" S. Muir, 6.45 p.m.

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…e cut to any length up to 500 ft., so …ing hose wastage.

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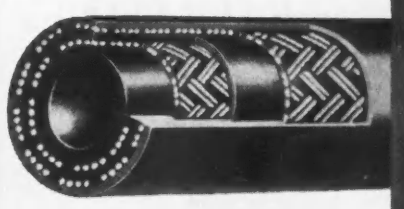
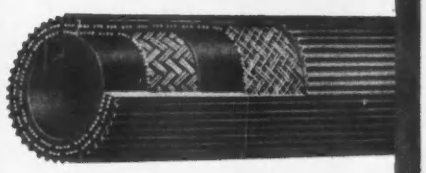
it lasts longer. Goodyear Long Length Hose has a non-porous tube and abrasion-resistant cover built of high grade compounds for maximum wear.

Light in weight and of balanced construction, Goodyear Long Length Air Hose is easy to handle and resists kinking. There are two types of this hose—Style A and Style B, both available with smooth or corrugated covers.



STYLE A *for service where oil mist may be present in the line, and where operating pressures up to 325 lbs. per sq. in. are used.*



STYLE B *for general, light and medium pneumatic tool service and working pressures up to 210 lbs. per sq. in.*

Full details of both types can be obtained from Industrial Rubber Products Dept., Goodyear, Wolverhampton. We will also be pleased to advise on any air hose problem you have.

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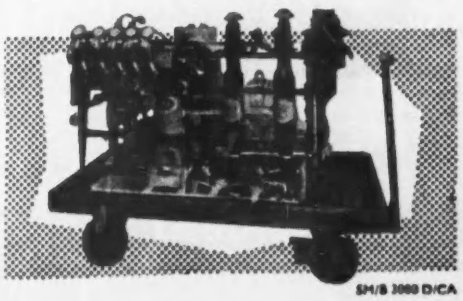
…knowledgments to B.O.A.C., The Bristol Aeroplane Company Limited and Williams & James (Engineers) Limited.



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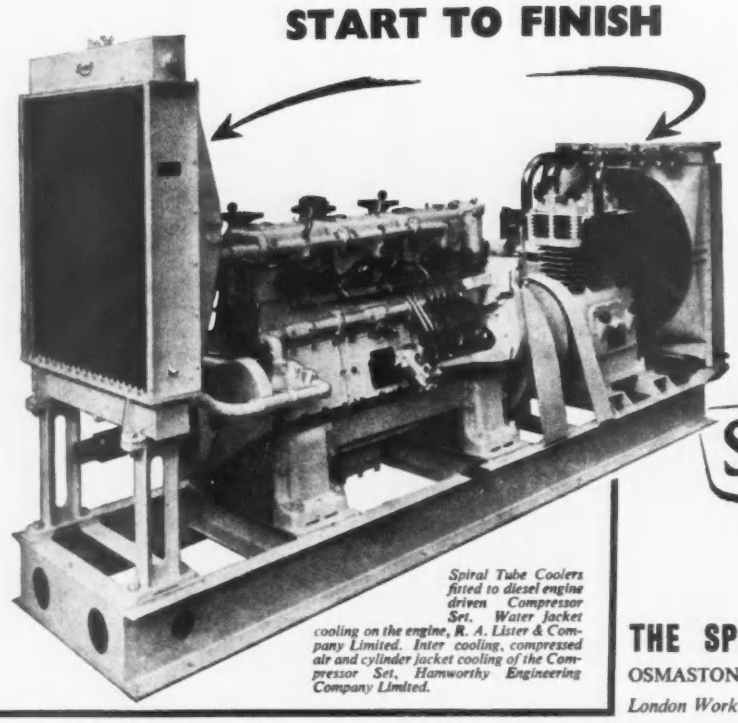

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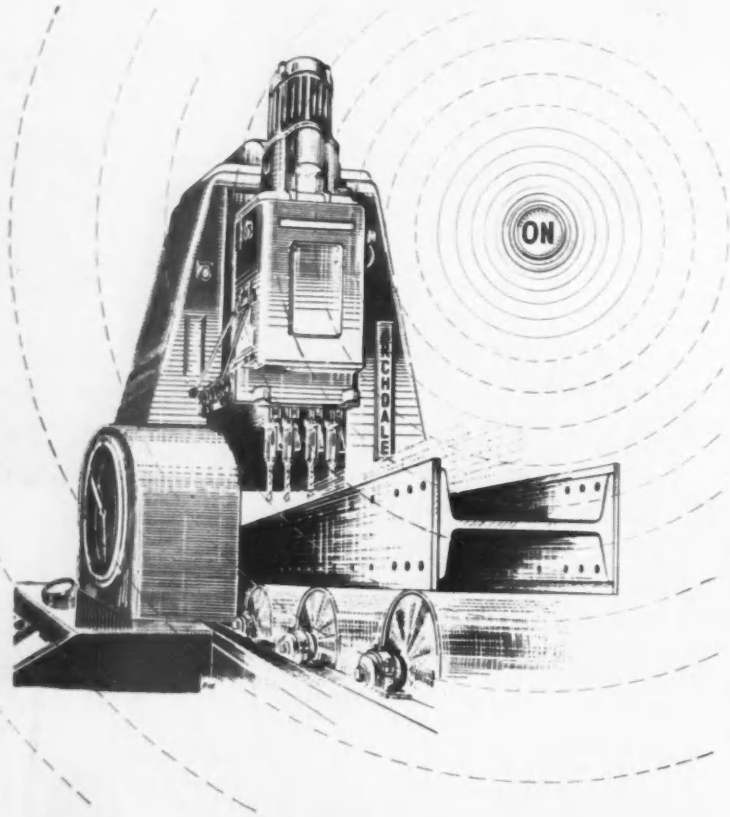

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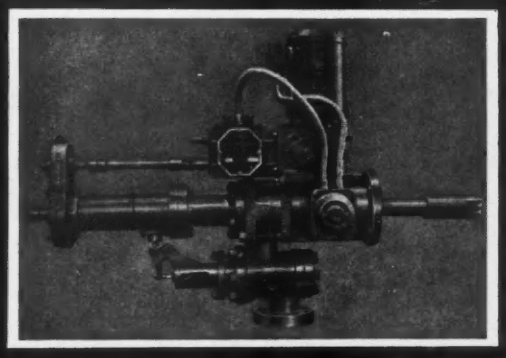

THE BLOWER: The complete operating cycle is in one motion and is driven through a compact mechanism by a non-reversing motor. When the operating shaft is rotated, the nozzle advances, the steam ports open and, at the same time, rocking motion is automatically transmitted to the nozzle. The uni-directional motor eliminates the bulky contactor gear used with reversing motors and reduces electrical maintenance by being of simpler and more rugged construction.

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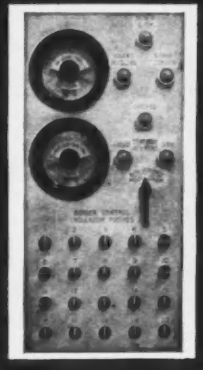

AND THE CONTROL PANEL Simple controls to operate the automatic sequence are grouped on this small unit which takes up little space on the main boiler control panel.

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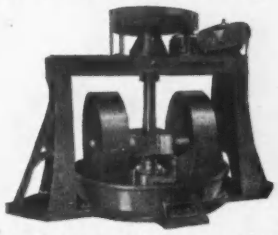

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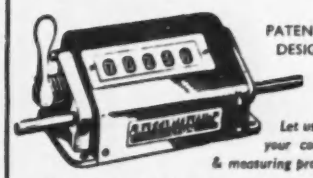

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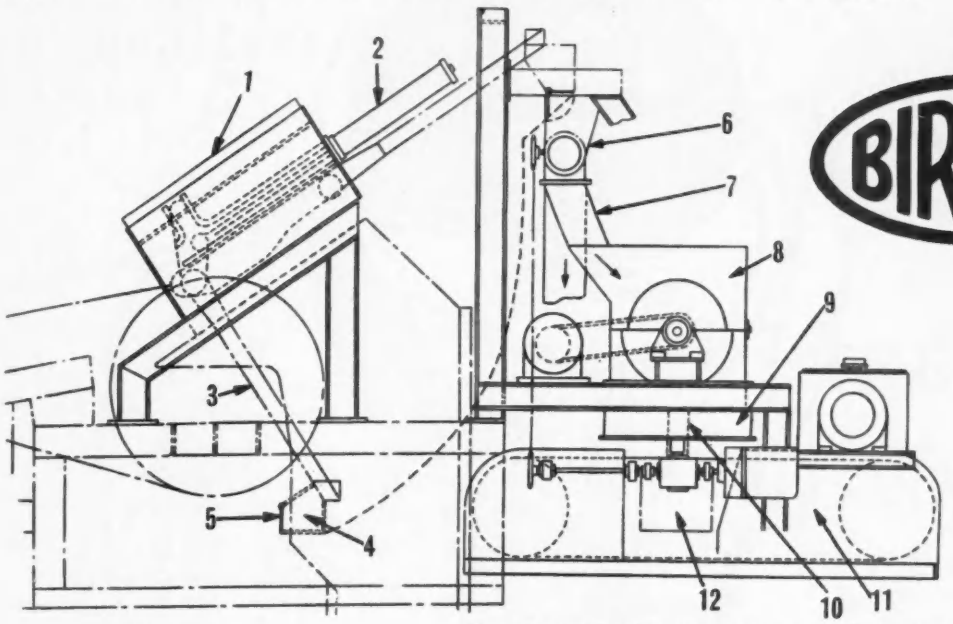

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2 Hydraulic Cylinder*
3 Swinging Arm*
4 Bucket*
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7 Removable chute
8 Crusher
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10 Discharge chute from rotary feeder
11 Slotted belt type secondary sampler
12 Container for final sample

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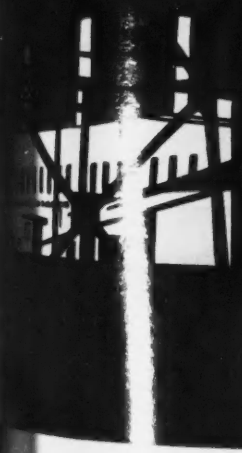
* Primary Sampler component



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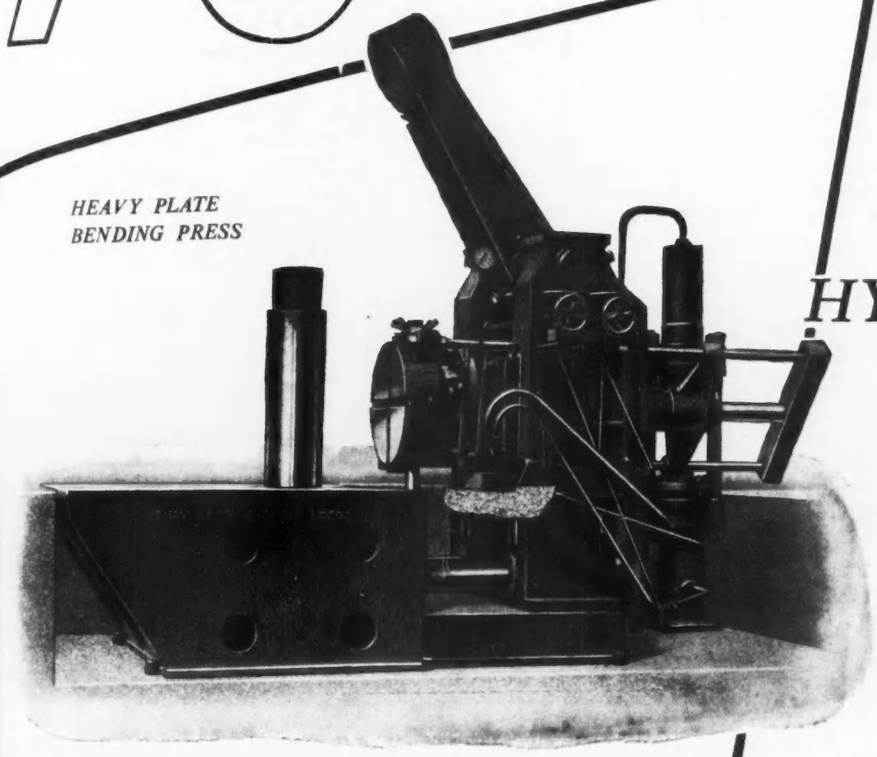

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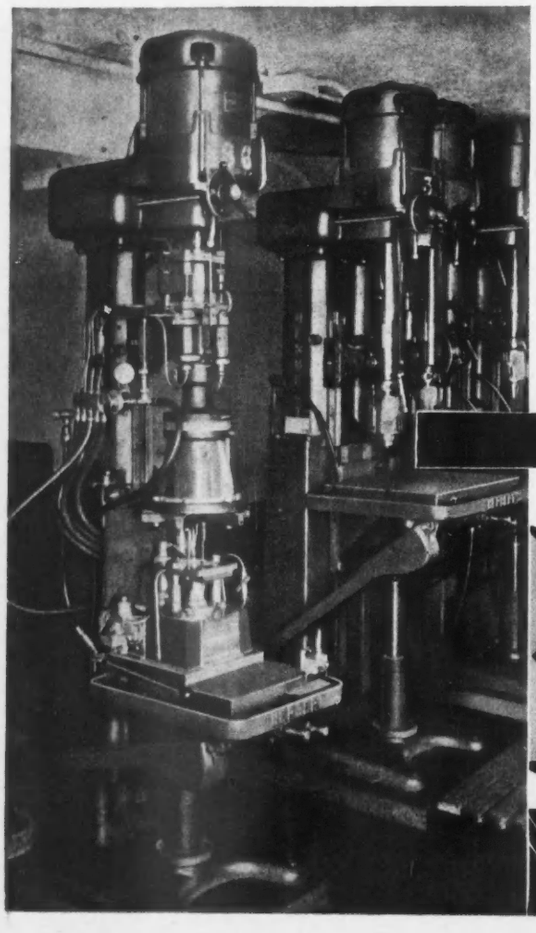

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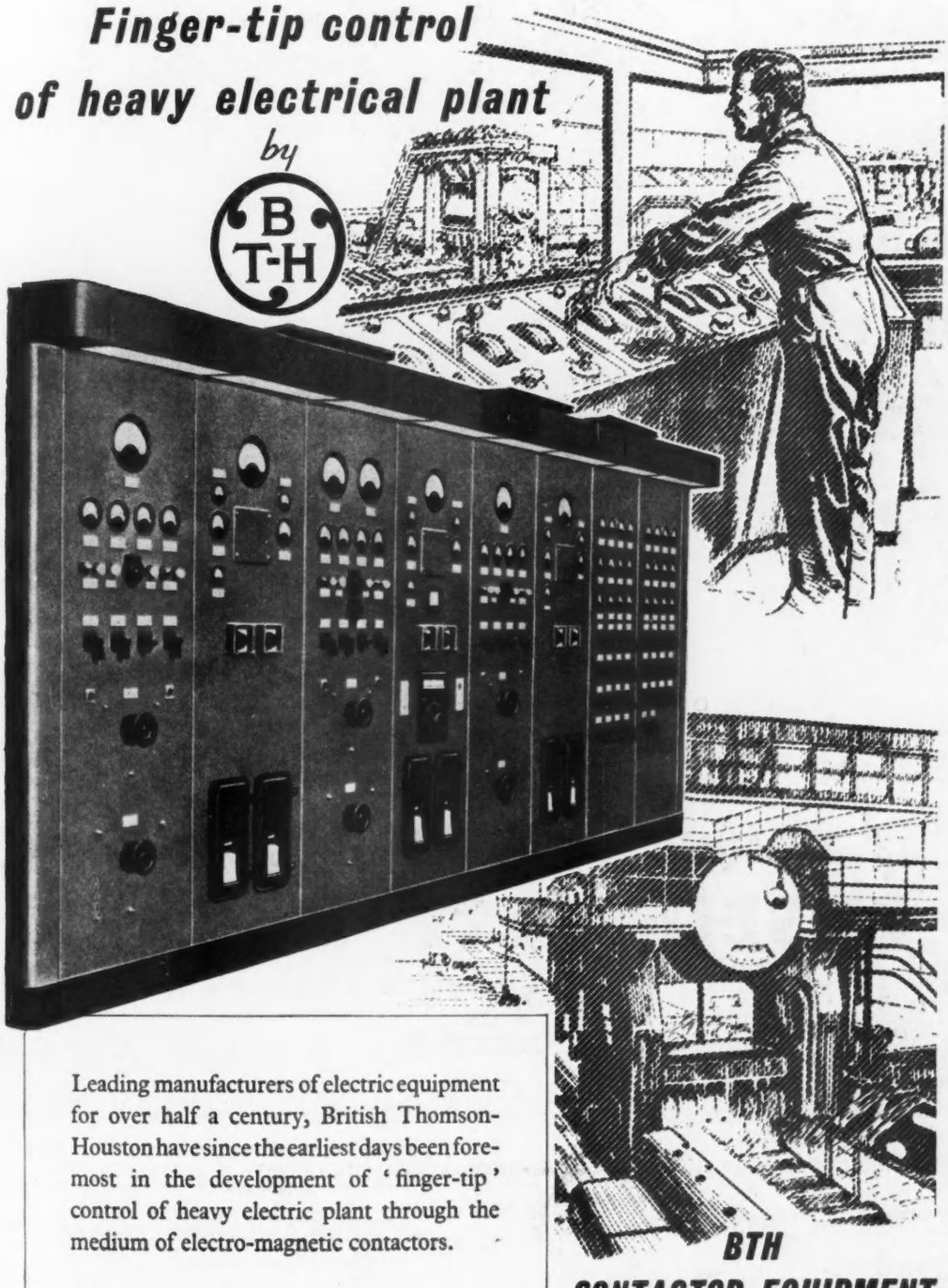

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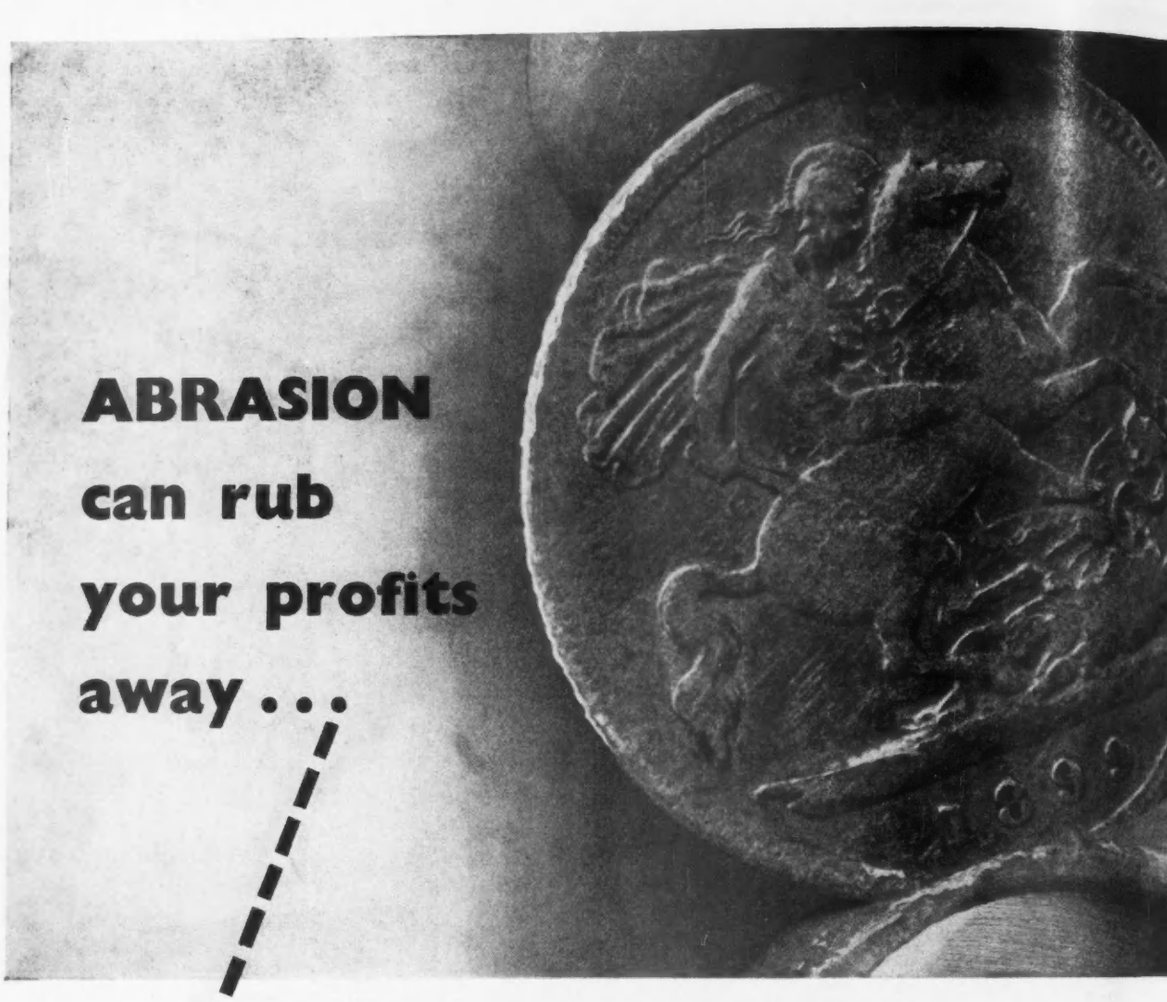

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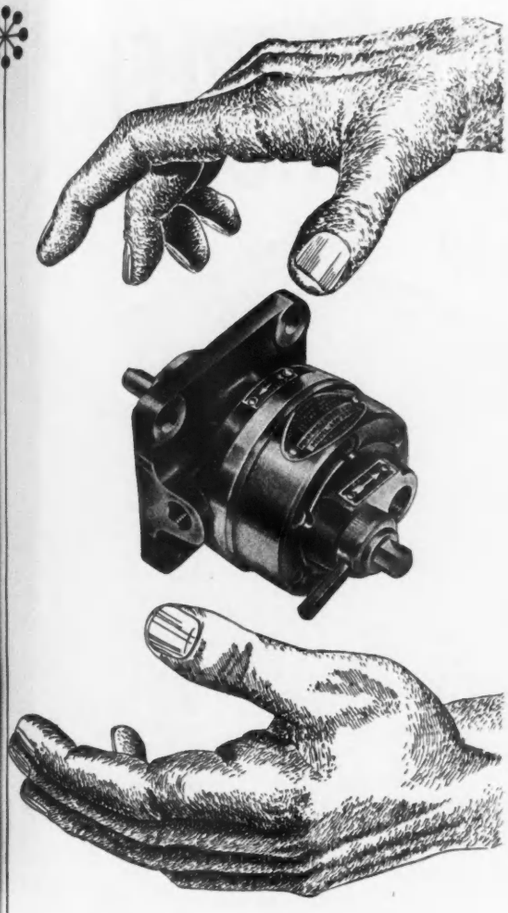

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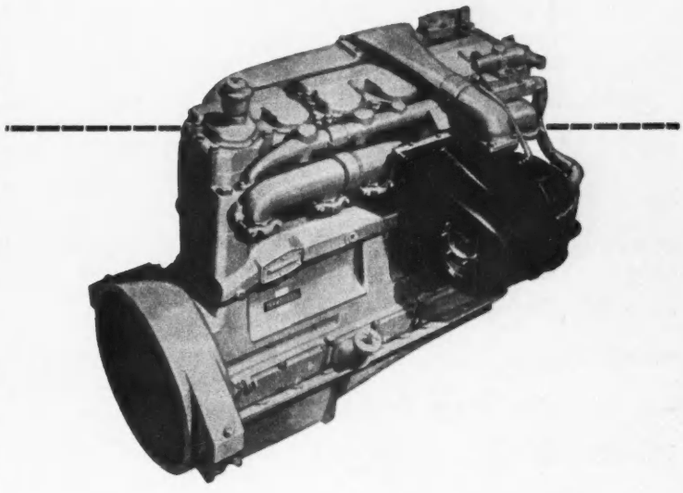

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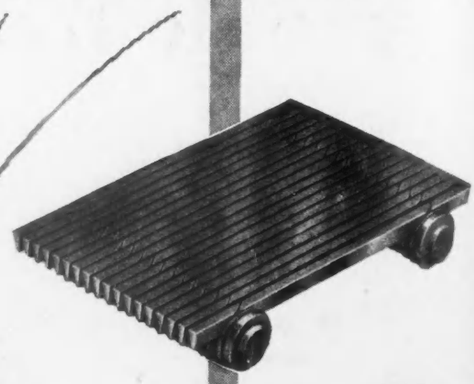

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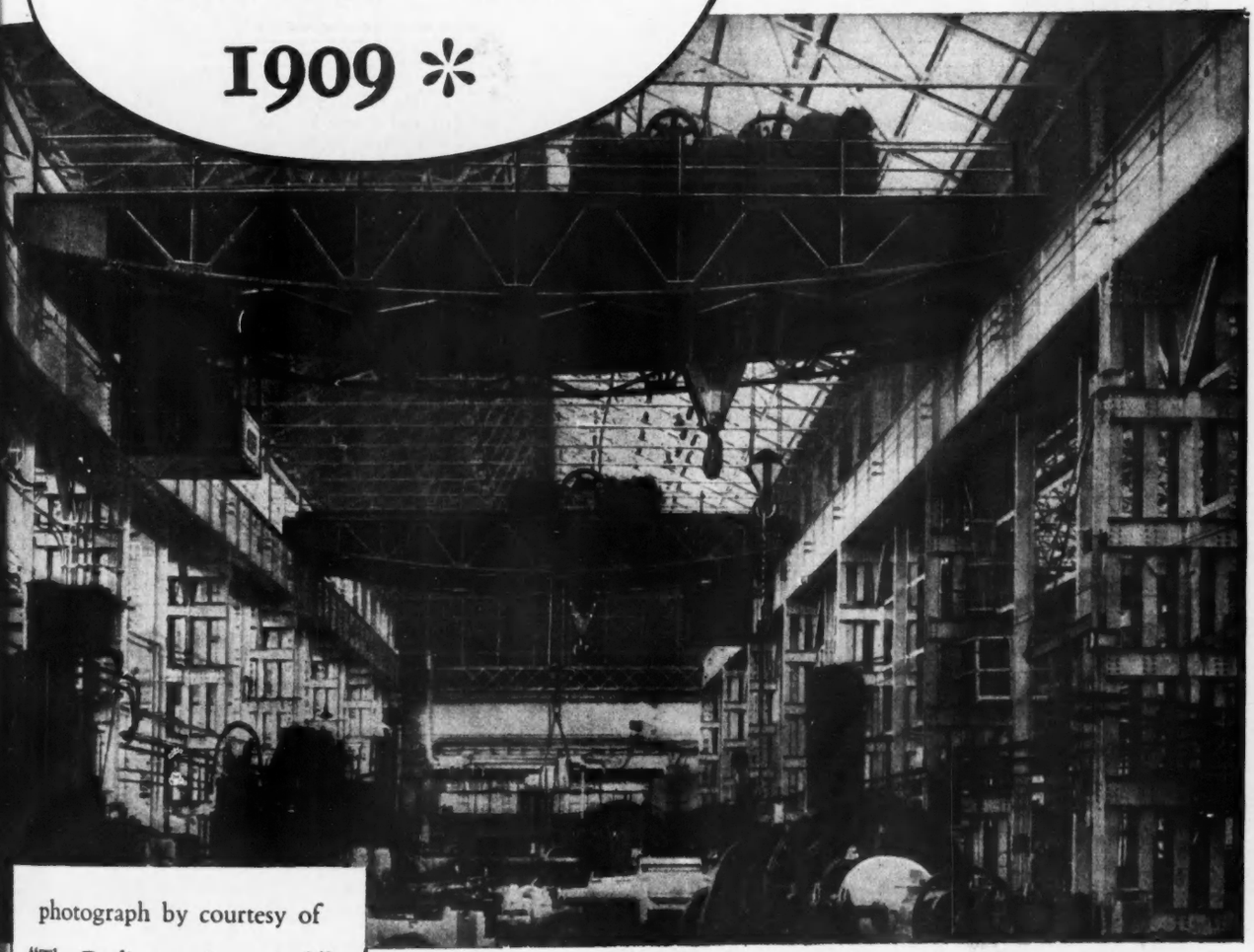

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Allowing for variations in the mechanical properties and other characteristics which may be imparted to a casting in any given steel composition by appropriate heat treatment, this range of steels provides for most combinations of mechanical stressing required for the functioning of the general run of engineering plant, equipment and machine components. This range of steel compositions, of course, does not cover applications involving mechanical and thermal stressing of a *very high order*, nor those used in *exceptionally corrosive service* conditions.

It is the Company's intention to increase the range of steel compositions handled as soon as the necessary techniques can be introduced, and established, on the foundry floor.

* * * * * * * * * * * * * * *

Since the opening of the Company's new laboratories in June 1956, all foundry operations have been subjected to close technical controls. The illustration shows a view of the Furnace Laboratory, which is located immediately adjacent to the Melting Bay.

The Company welcomes enquiries for steel castings within the weight range and specification range given above, and it is at all times ready to undertake prototype work in collaboration with a customer's design departments.

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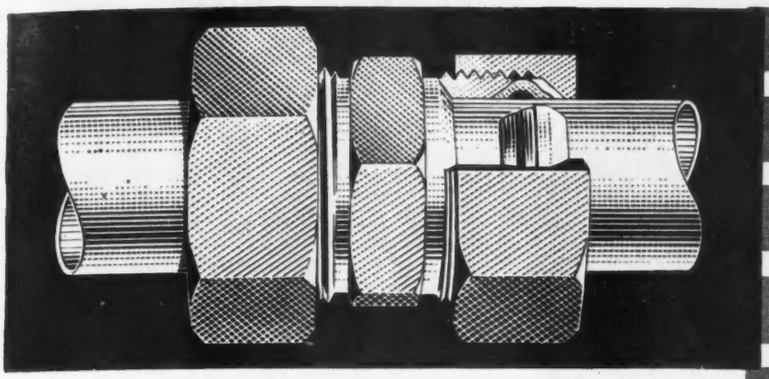

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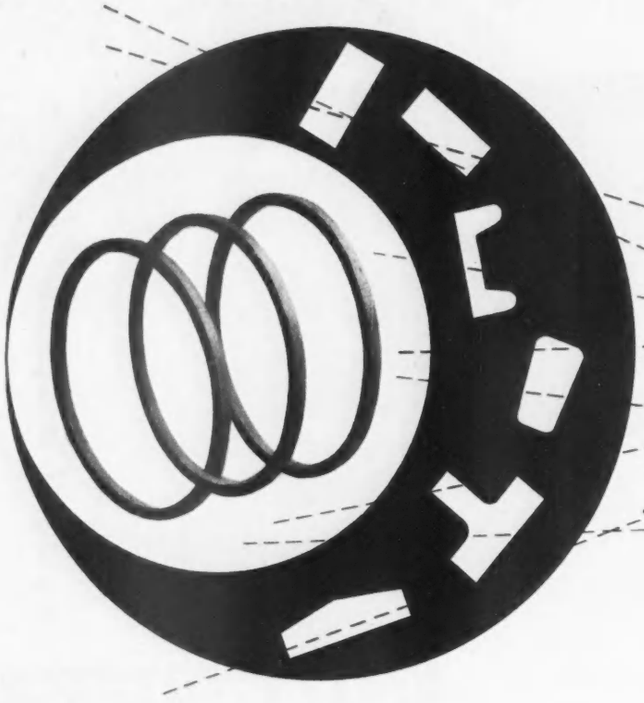

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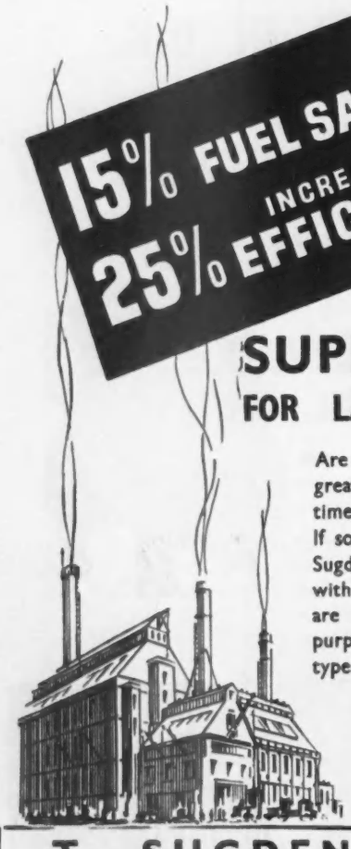

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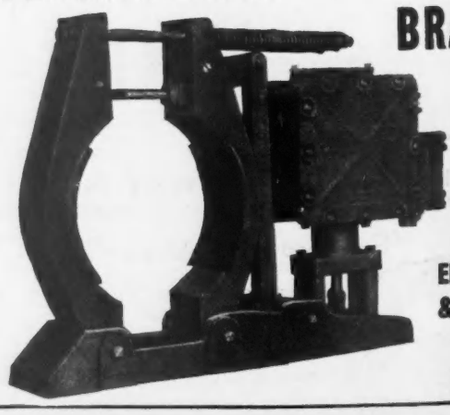

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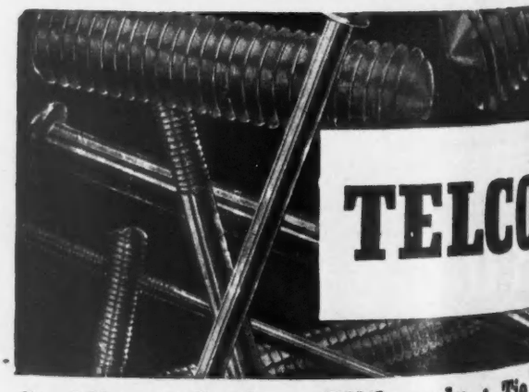

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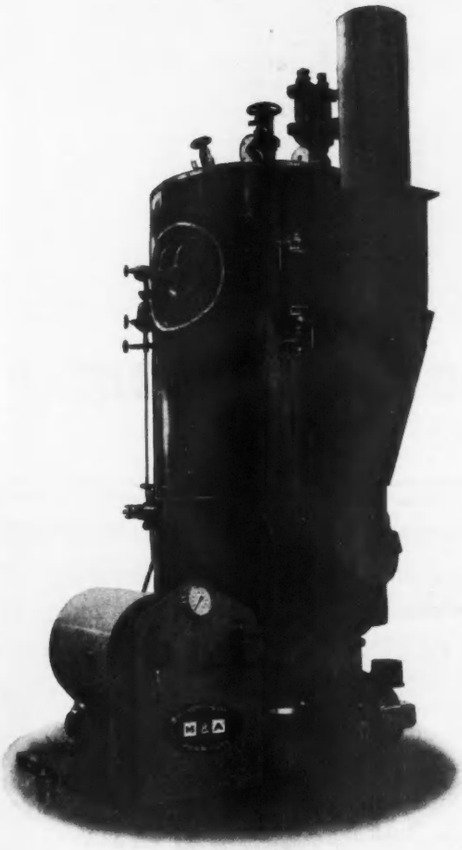

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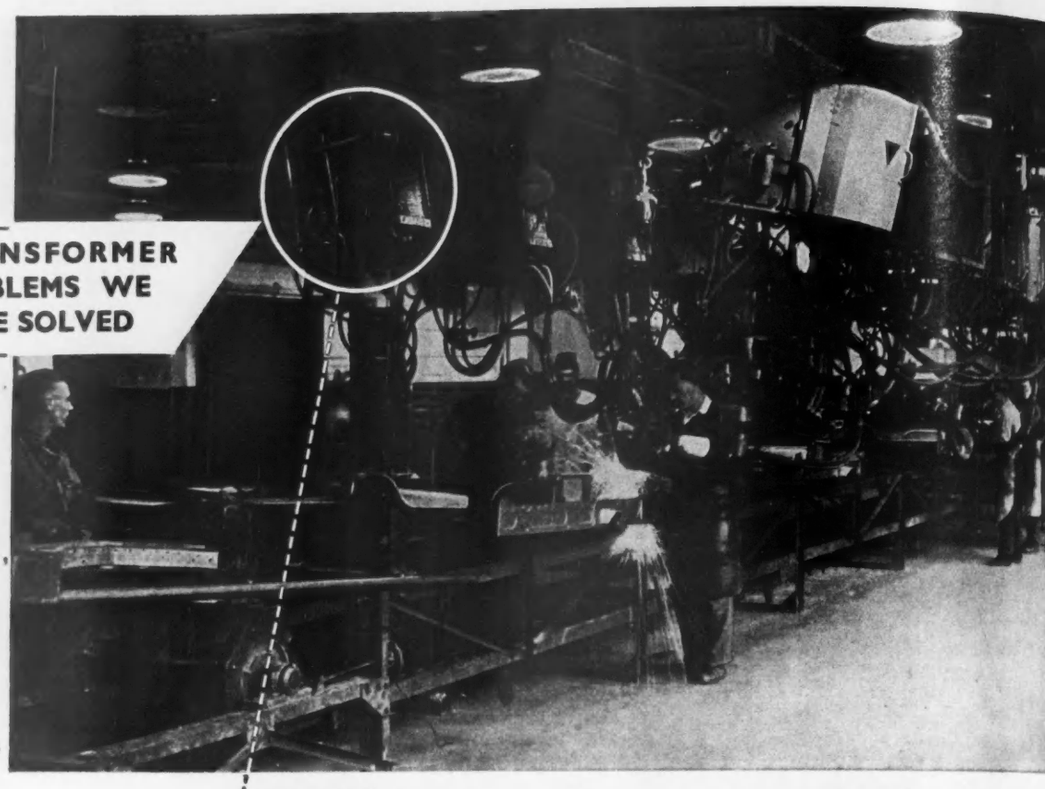

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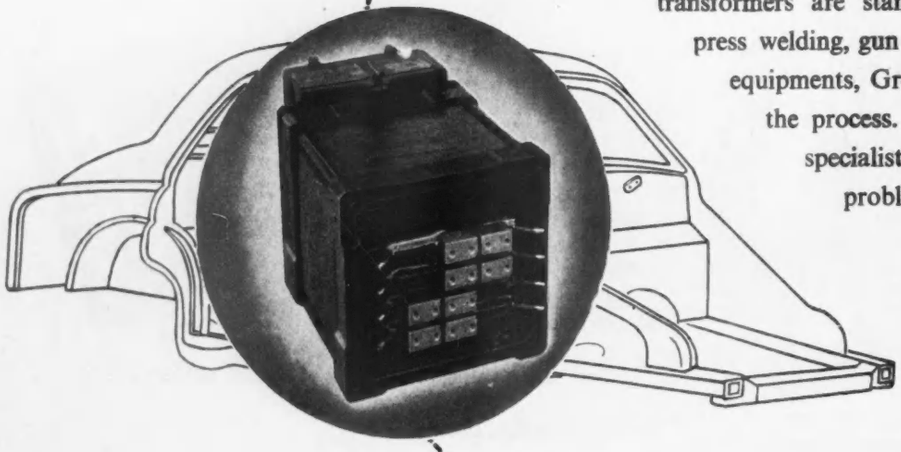

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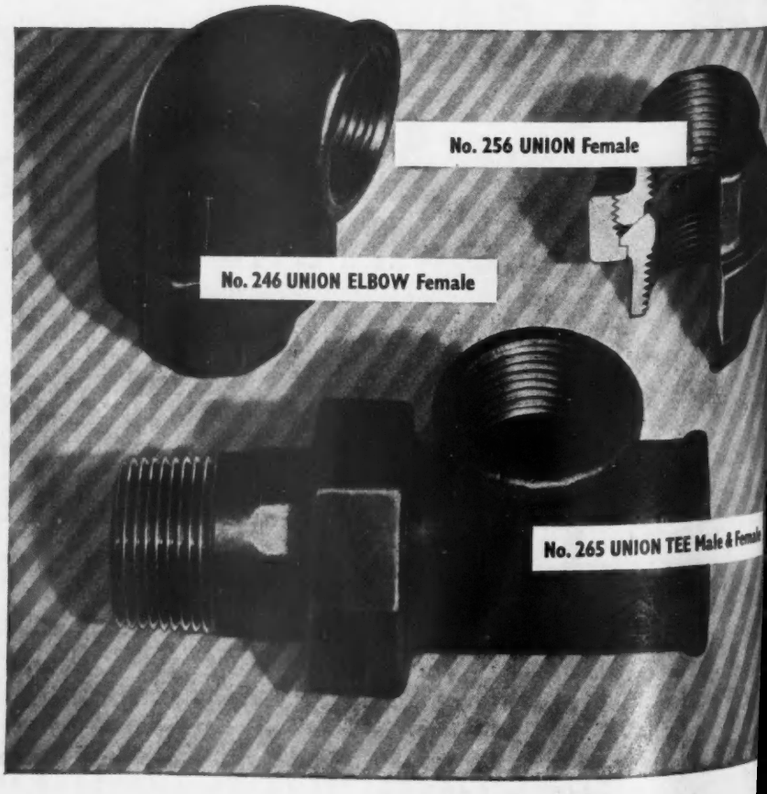

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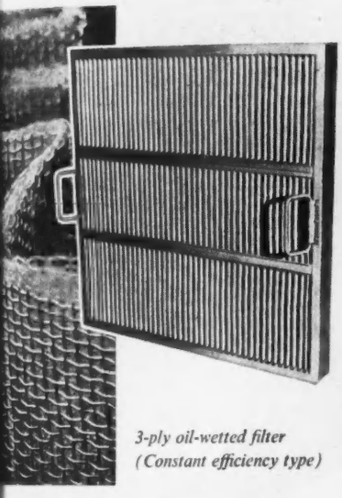

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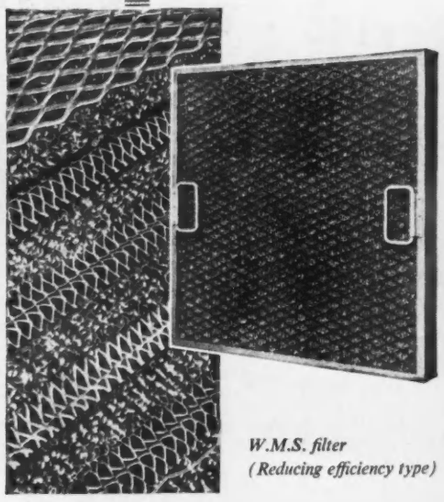

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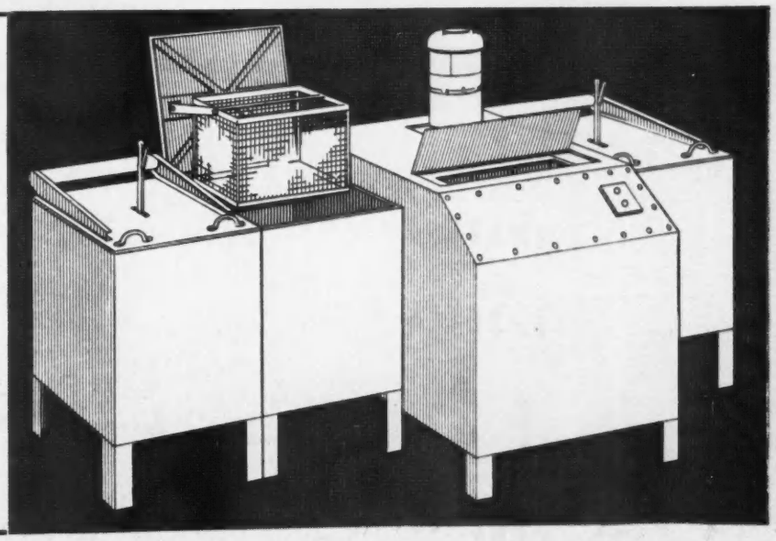

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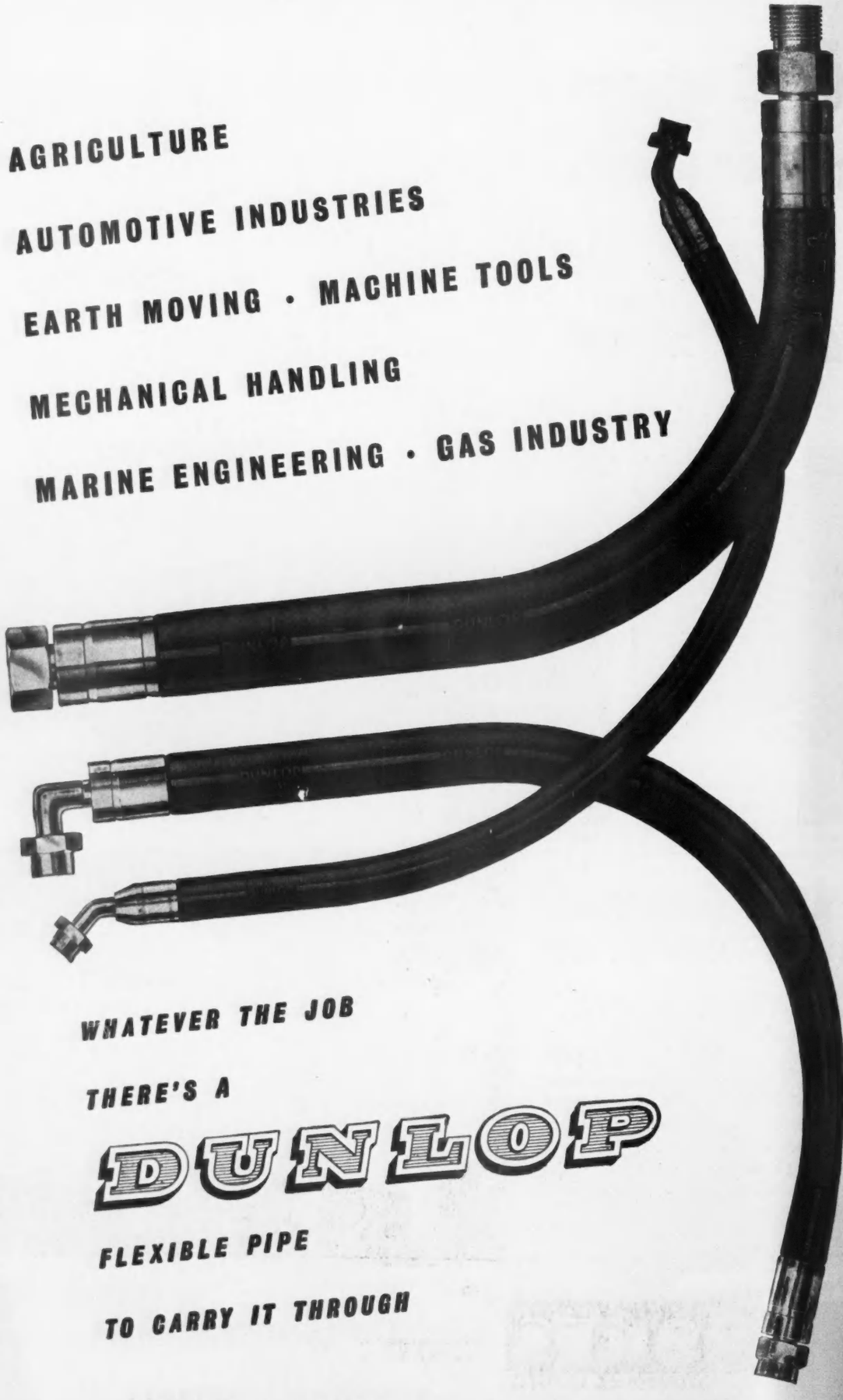

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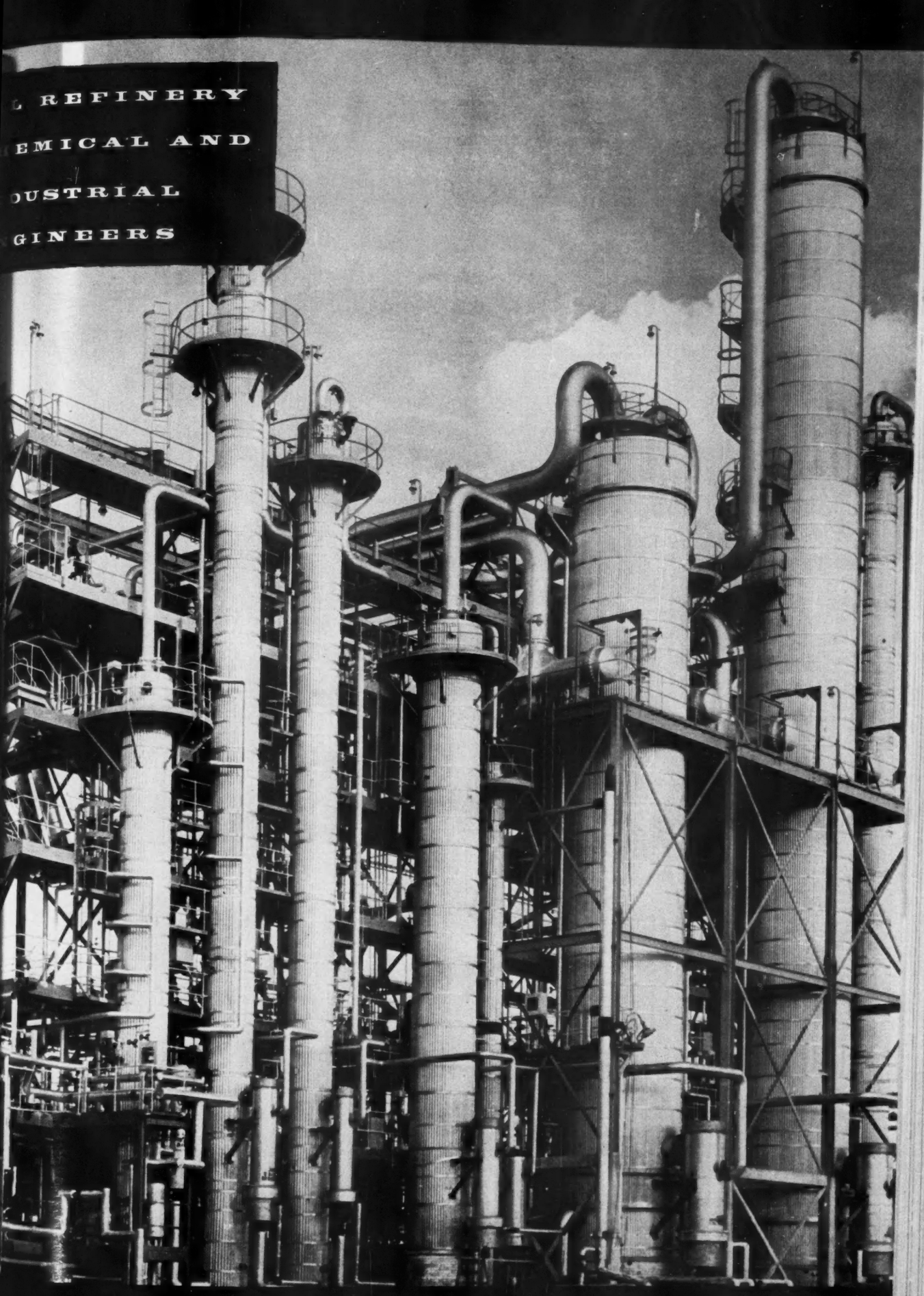

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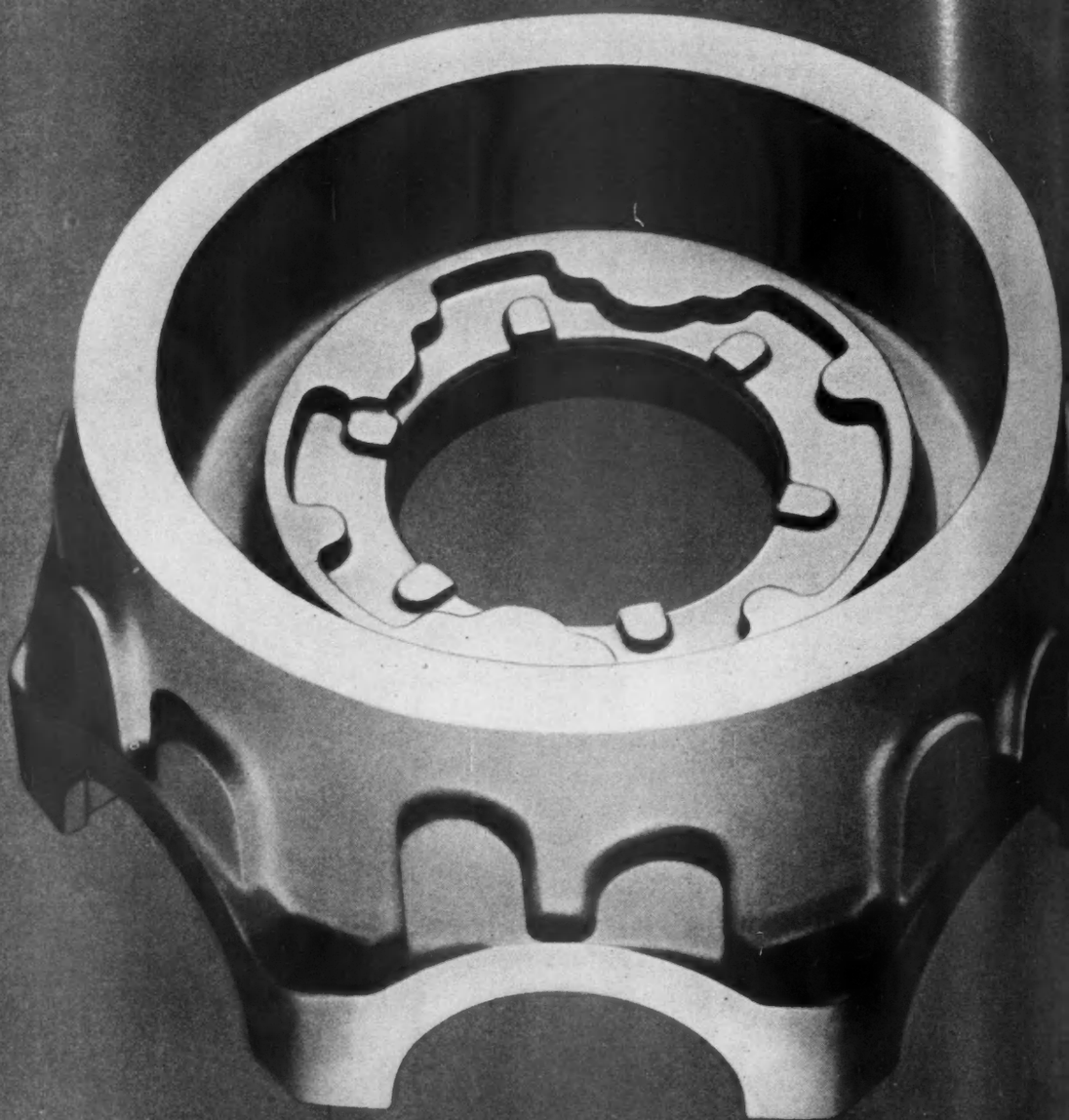

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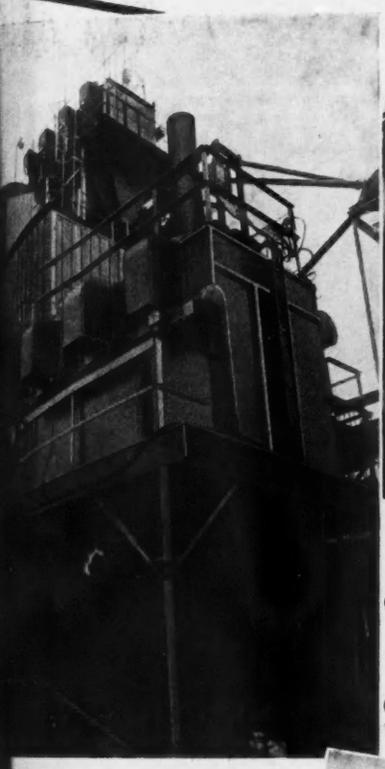
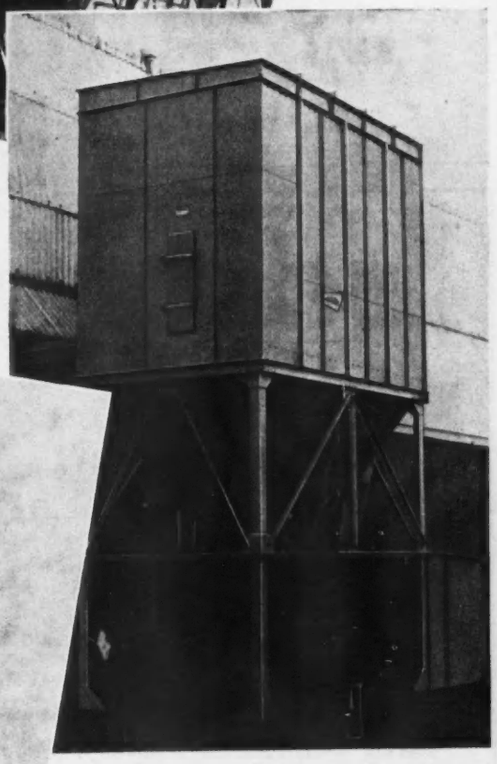


(Above) Two large collectors designed for handling carbon black, during erection at Messrs. Philblack Ltd., Avonmouth. Photograph by courtesy of Messrs. Philblack Ltd., and Messrs. E. B. Badger & Sons Ltd.

(Below) Special closed circuit, continuously operating chalk dusting plant. Photograph by courtesy of Messrs. Rubber Regenerating Co. Ltd., Manchester.



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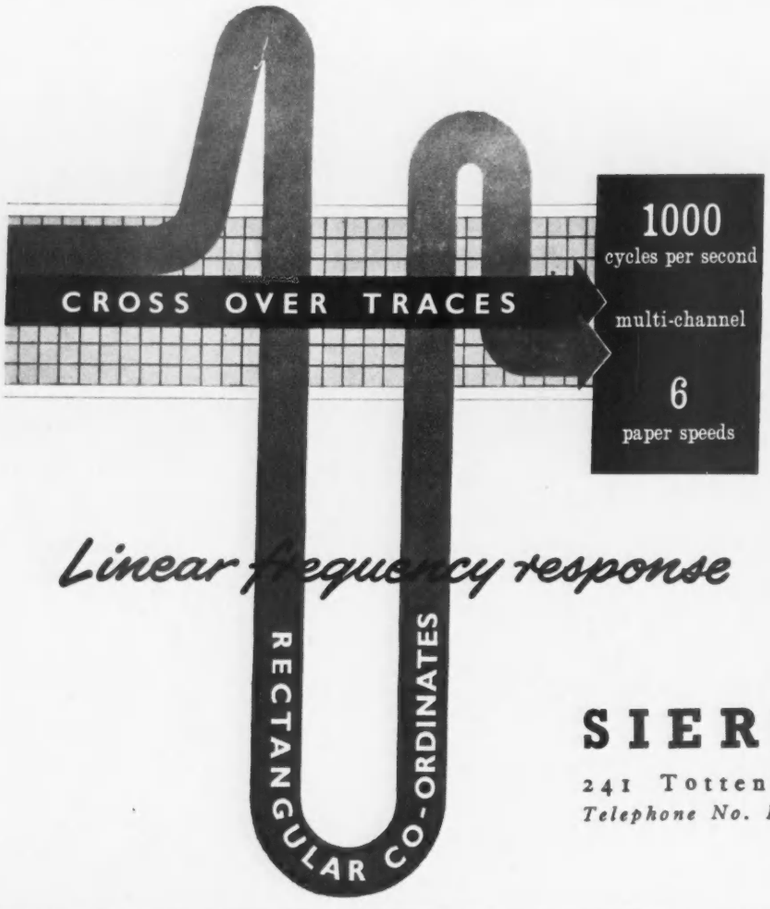

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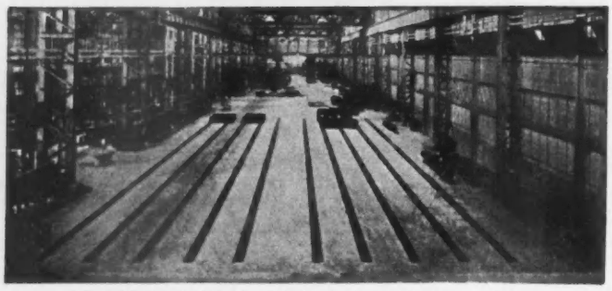

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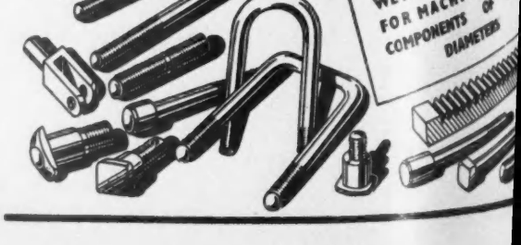

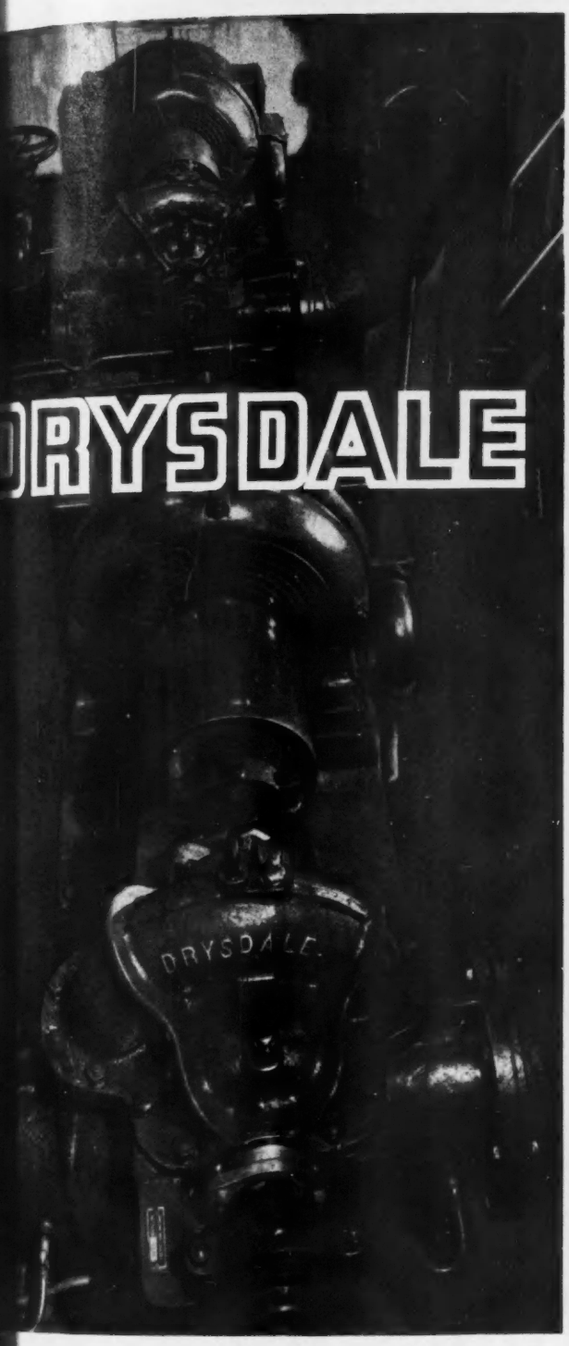

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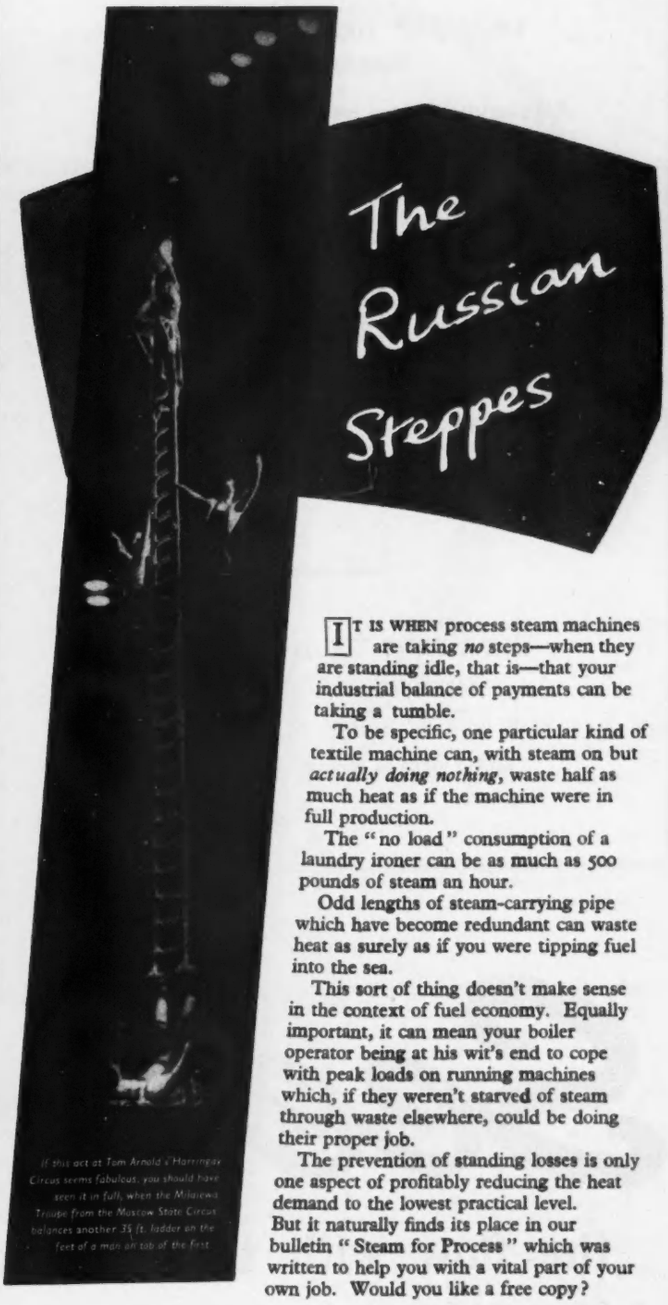

If this act at Tom Arnold's Harringay Circus seems fabulous, you should have seen it in full, when the Milaiewa Troupe from the Moscow State Circus balances another 35 ft. ladder on the feet of a man at top of the first.

IT IS WHEN process steam machines are taking *no* steps—when they are standing idle, that is—that your industrial balance of payments can be taking a tumble.

To be specific, one particular kind of textile machine can, with steam on but *actually doing nothing*, waste half as much heat as if the machine were in full production.

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Odd lengths of steam-carrying pipe which have become redundant can waste heat as surely as if you were tipping fuel into the sea.

This sort of thing doesn't make sense in the context of fuel economy. Equally important, it can mean your boiler operator being at his wit's end to cope with peak loads on running machines which, if they weren't starved of steam through waste elsewhere, could be doing their proper job.

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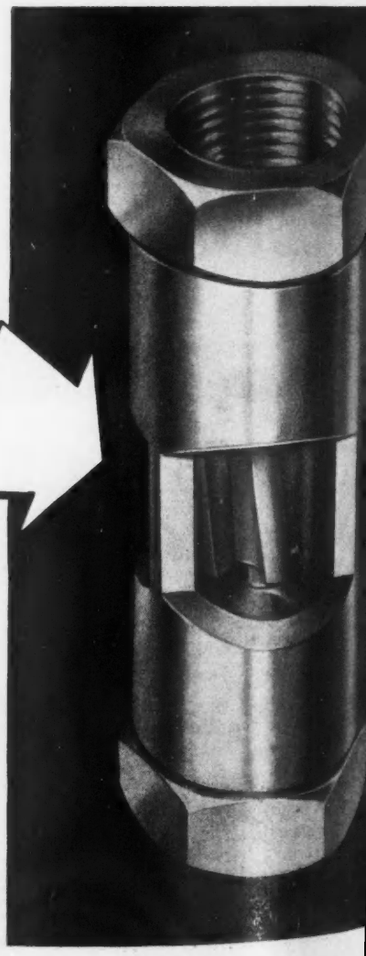

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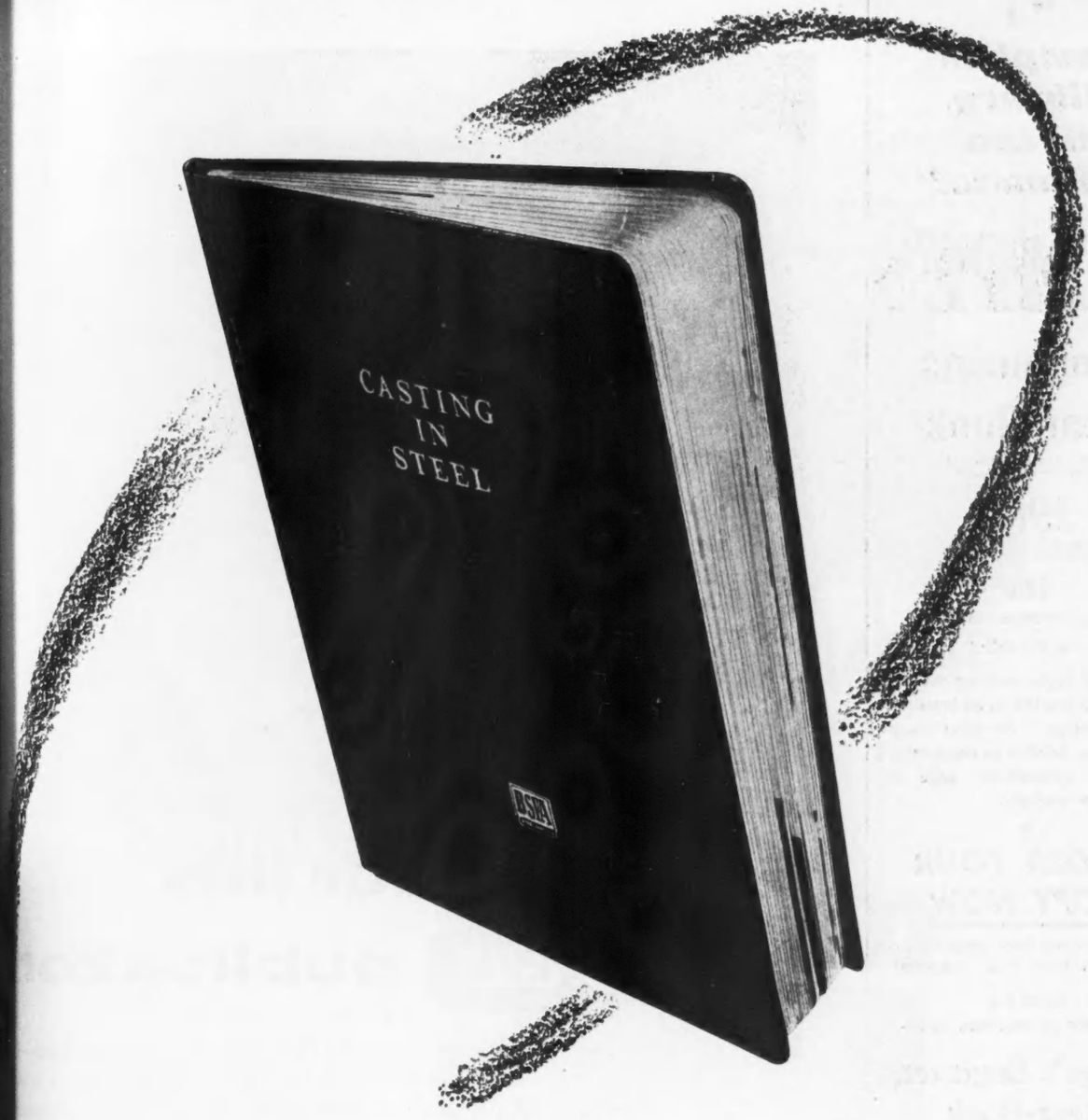

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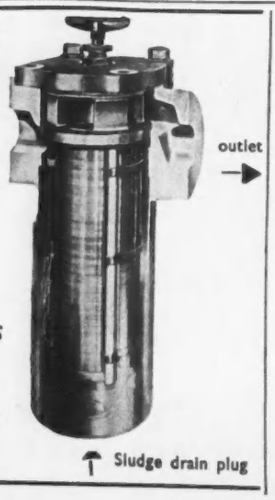

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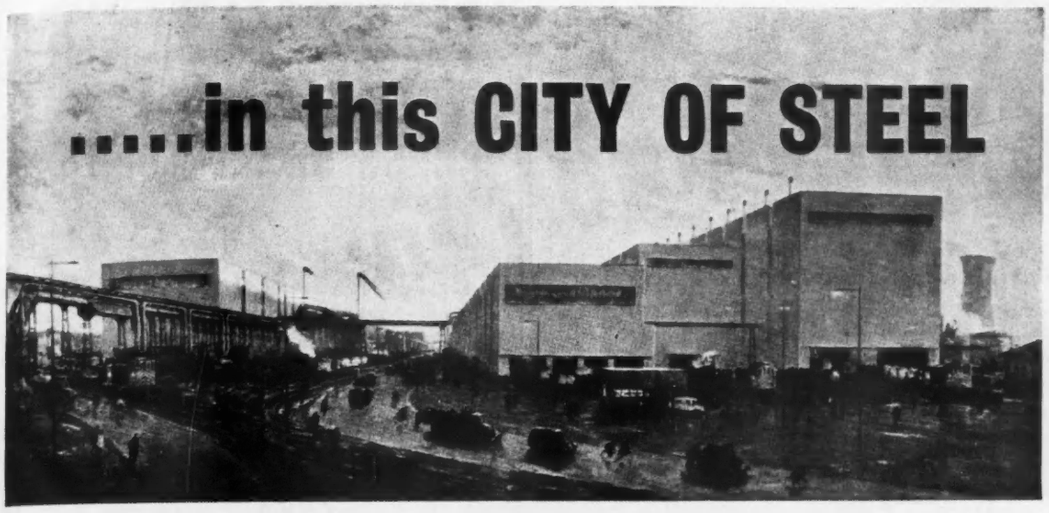

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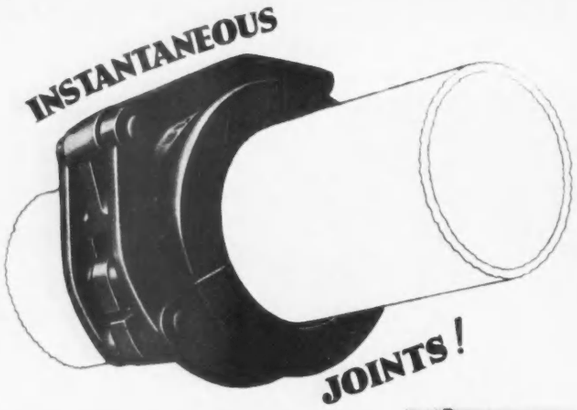

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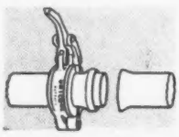
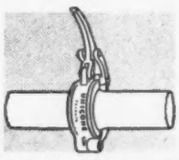
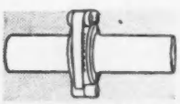

Rubber gasket in position and joint ready to pull over.


Pipe ends joined ready for locking.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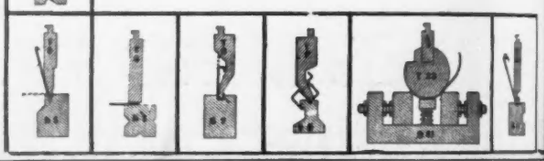

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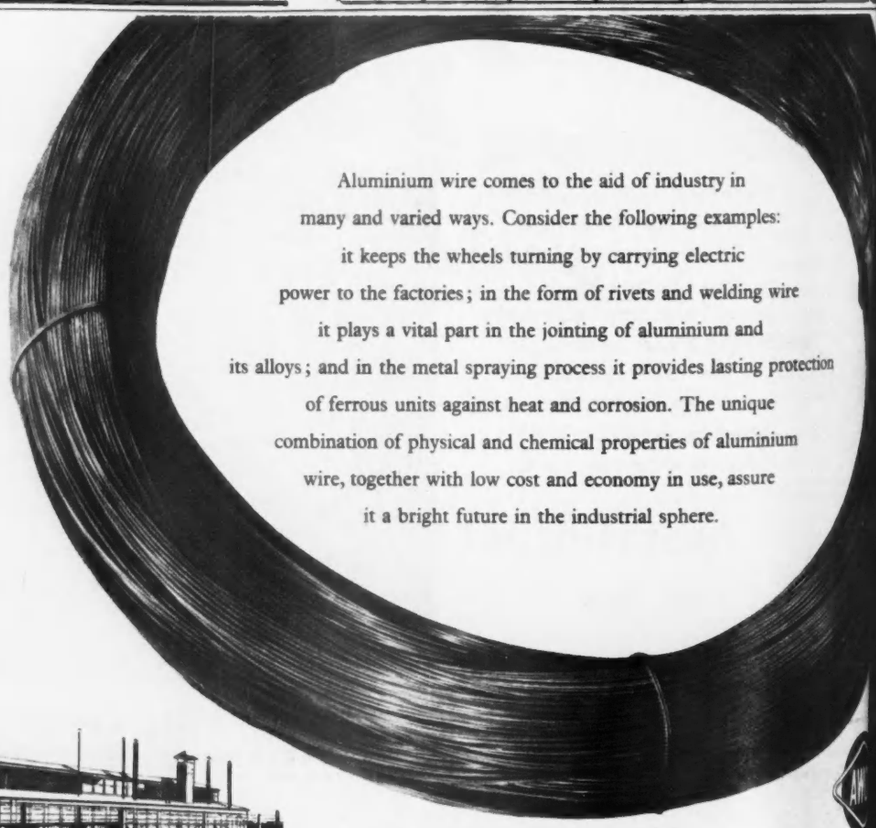

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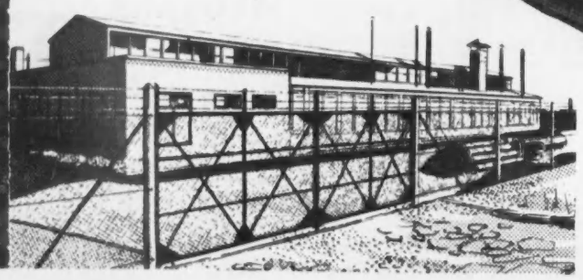

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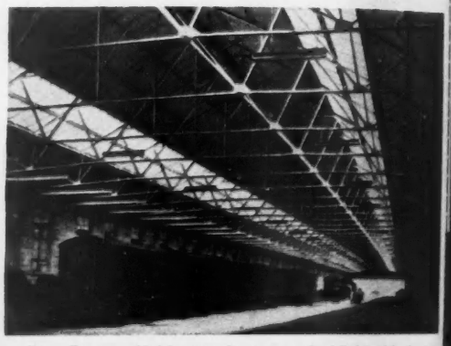

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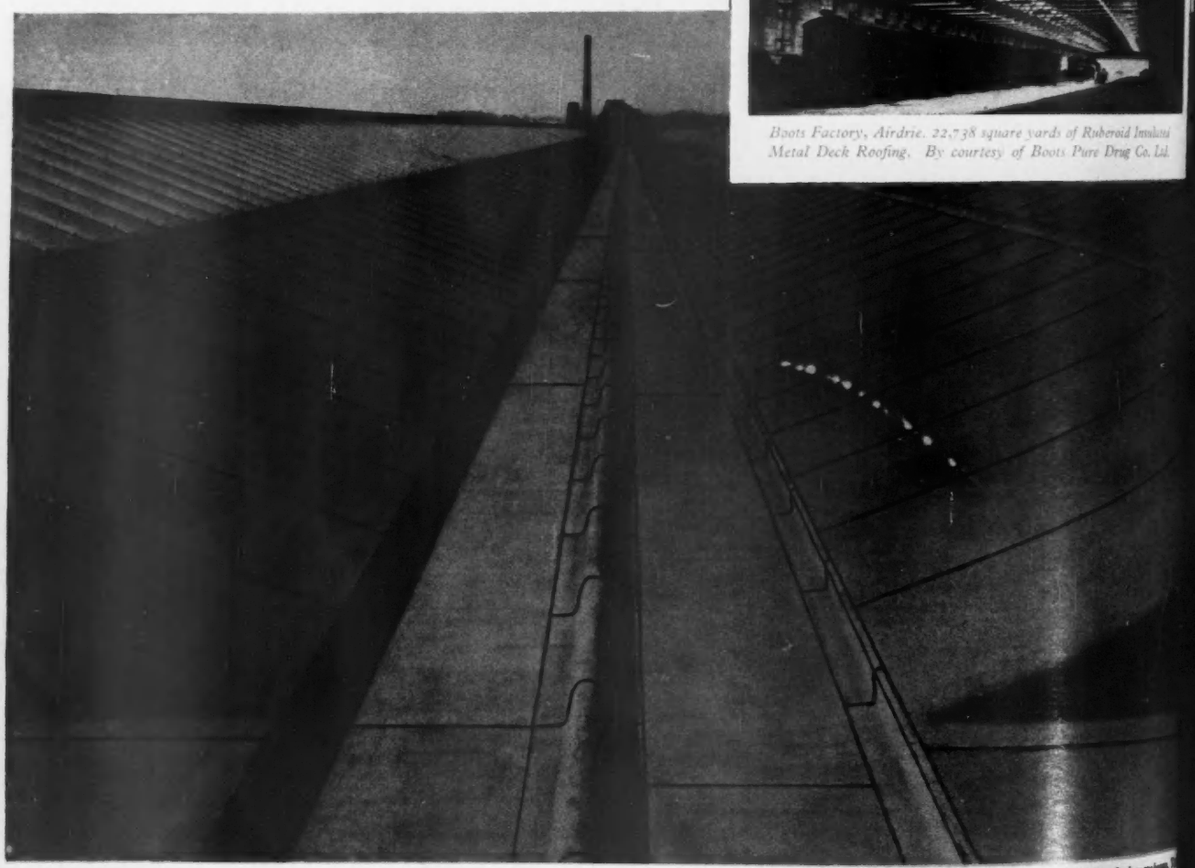

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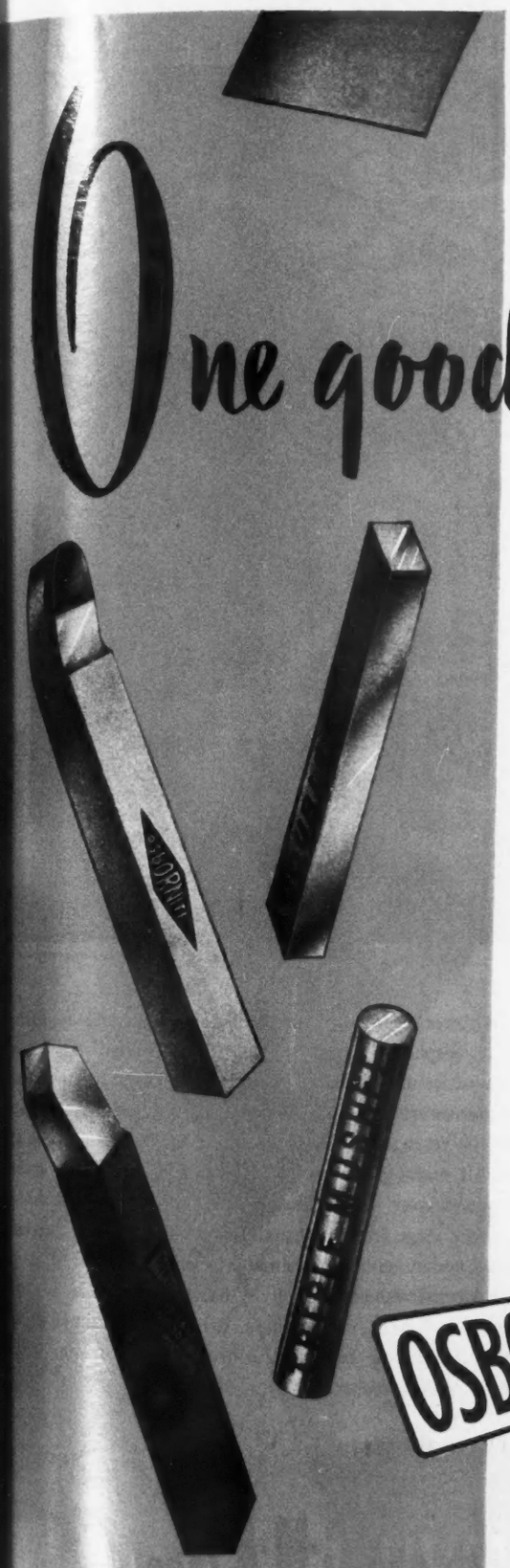

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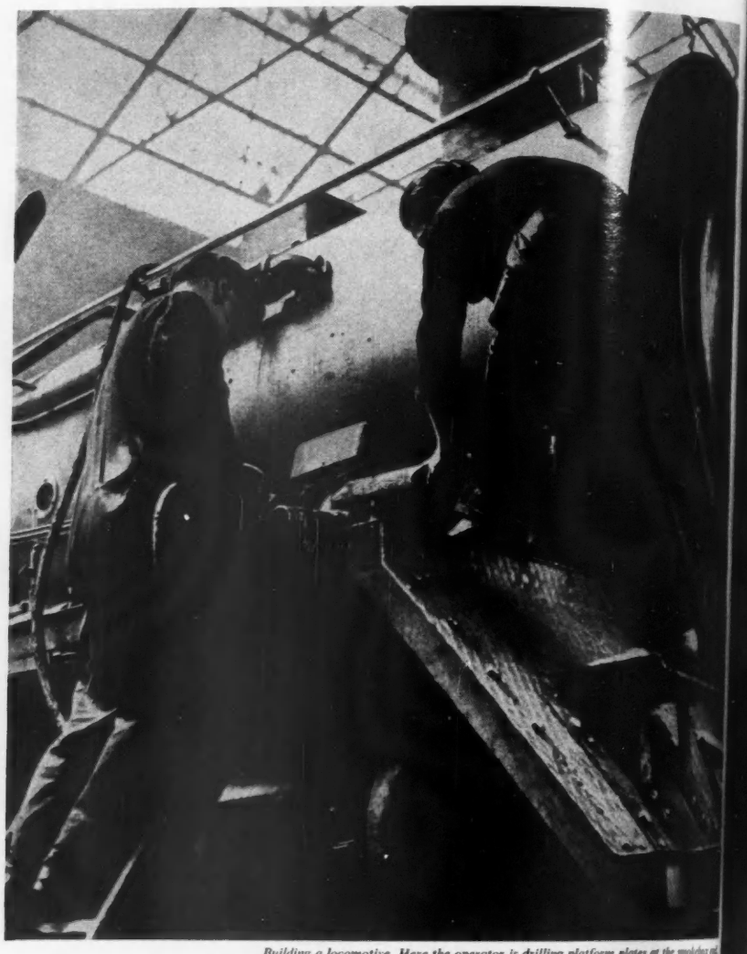

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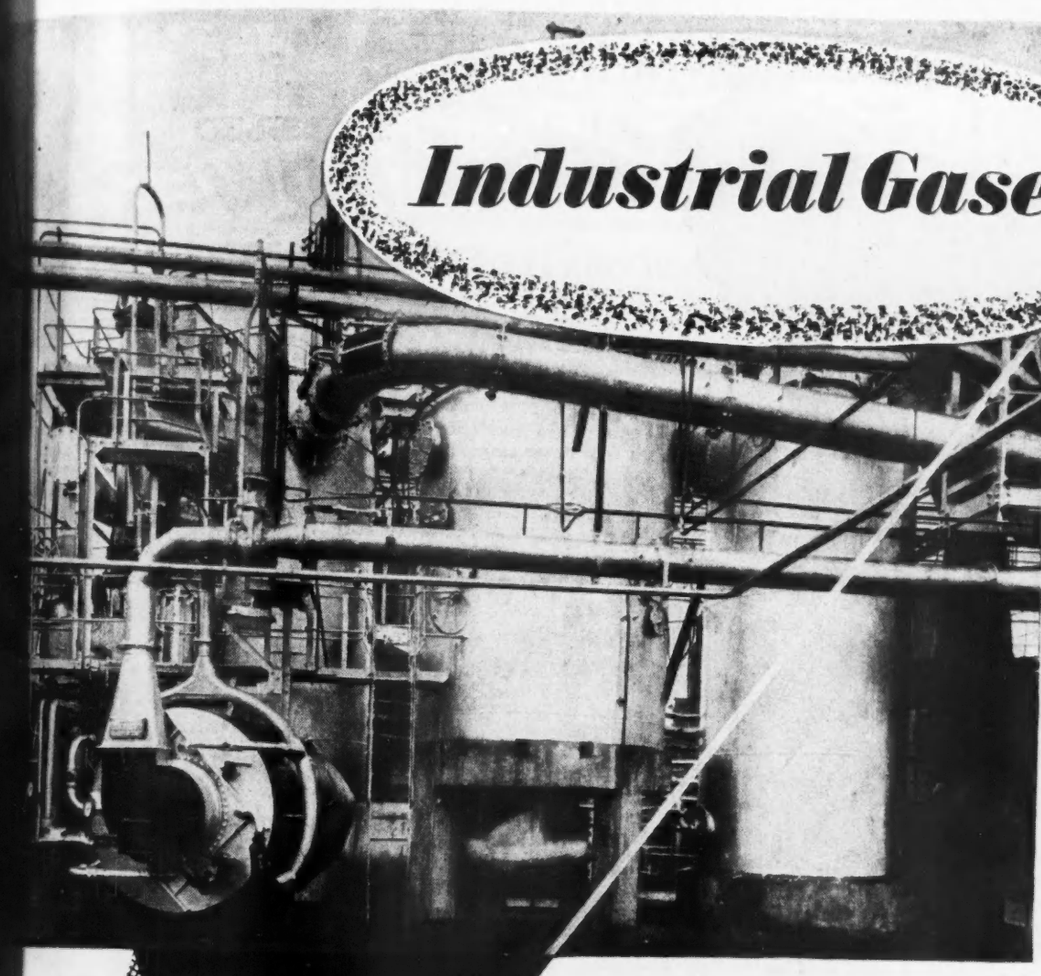

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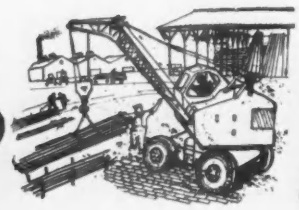

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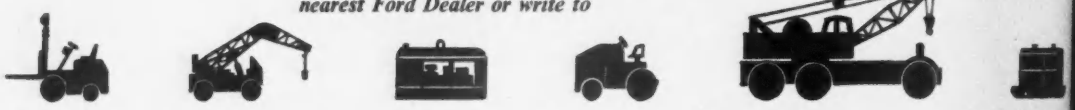

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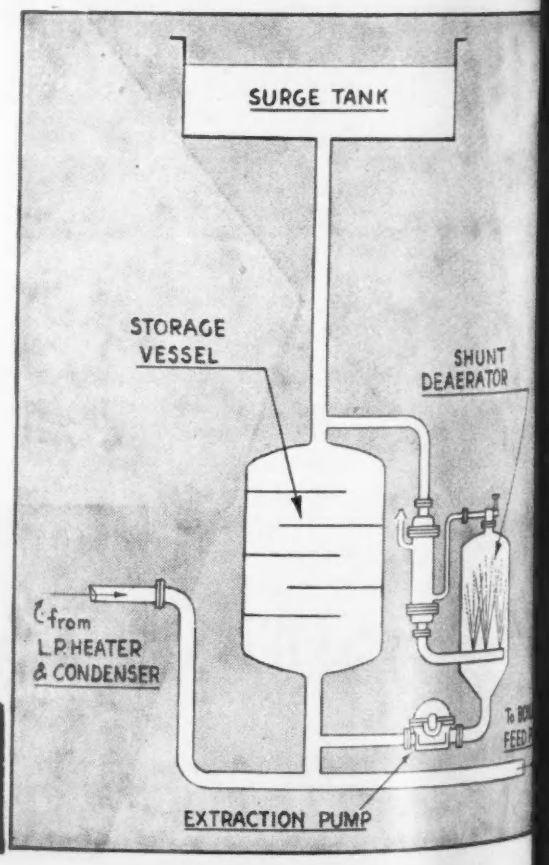

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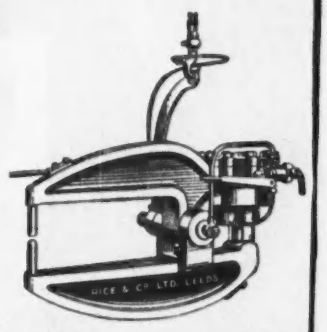

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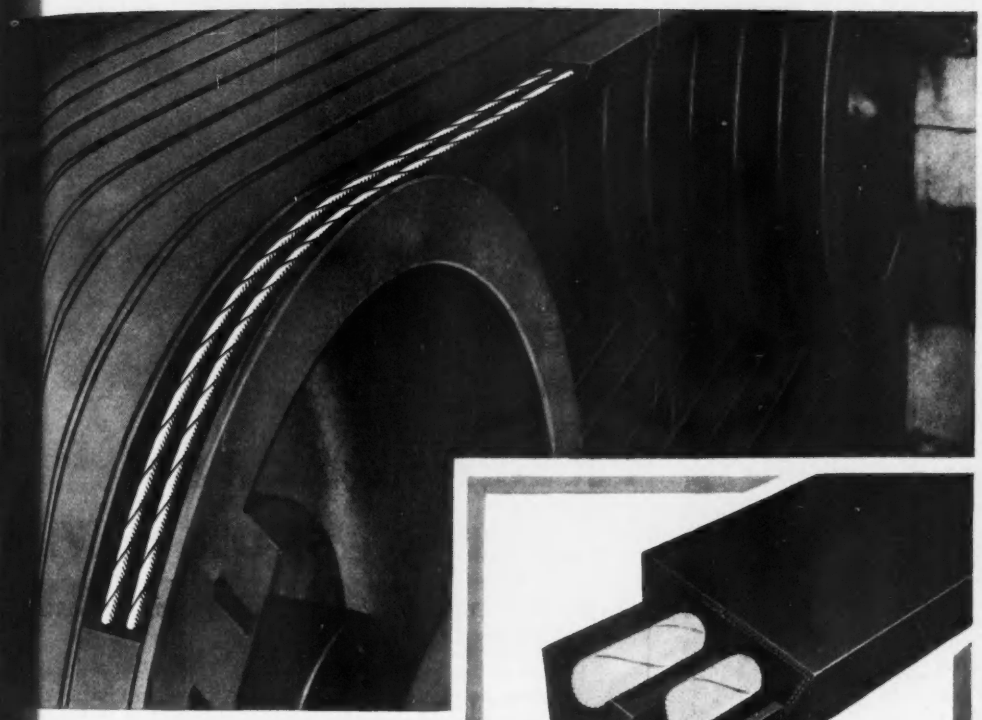

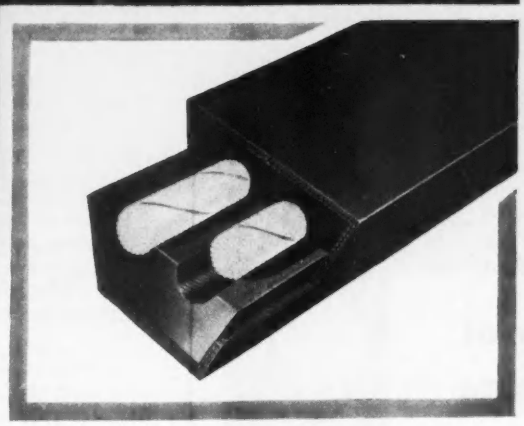

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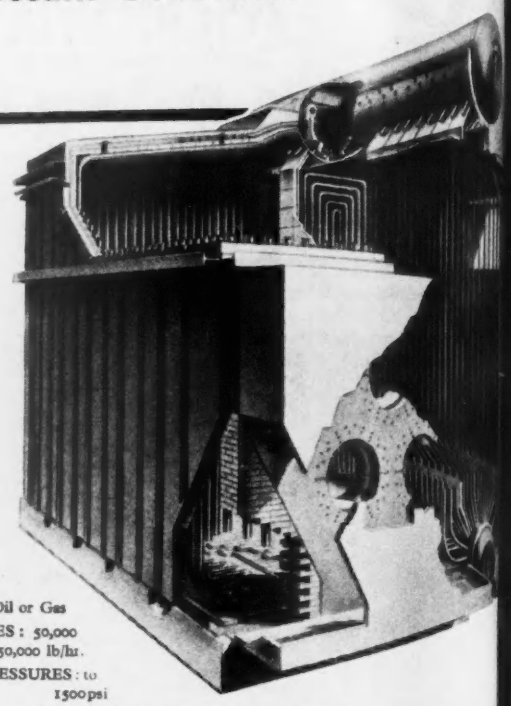
Series "SC" STANDARD
Steam Generator



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Series "SC" Steam Generator is pre-engineered, standardized design, with all exterior and structural details fixed. Available in nine sizes, with capacities of 50,000 to 150,000 lb. steam per hr. it incorporates advanced design features that make possible important savings in industrial steam costs.

Burners, controls, upper drum mountings and other equipment requiring attention are located at the front of the unit. Heat recovery equipment and fans can be placed near the operating side for either single or multi-unit installations, providing maximum accessibility and ease of operation.

Write today for further information. We shall be glad to explain how the Series "SC" Standard Steam Generator can meet your individual plant needs for power or process work.

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- *Over 19-foot firing depth.*
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- *Fully drainable superheater.*
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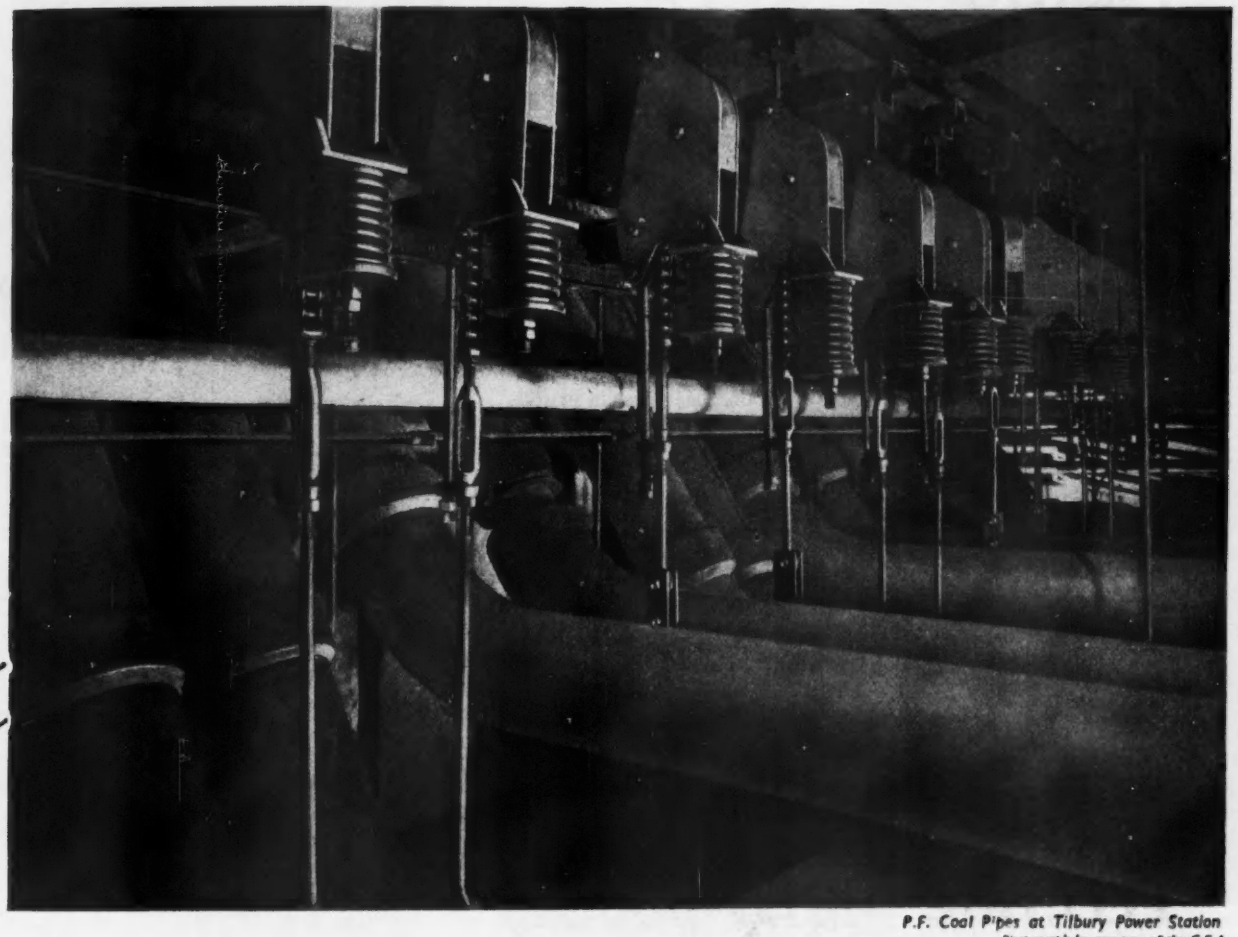

P.F. Coal Pipes at Tilbury Power Station
Photograph by courtesy of the C.E.A

For loads up to 4 tons and pipe movements up to 18".

High-pressure steam piping is subject to wide variations in temperature, which produce considerable expansion and contraction. Unless the pipe supports can absorb and compensate for this movement, severe stresses are set up which may result in fracture. The "Con-Ten" Pipe Support is designed to cradle any type of piping with constant tension under all conditions, throughout the range of movement. "Con-Ten" is installed, with eminently satisfactory results, in power stations, oil refineries, chemical and industrial plants throughout the world.

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CONSTANT TENSION PIPE SUPPORT

British Patent No. 474008. U.S.A. Patent No. 2129320

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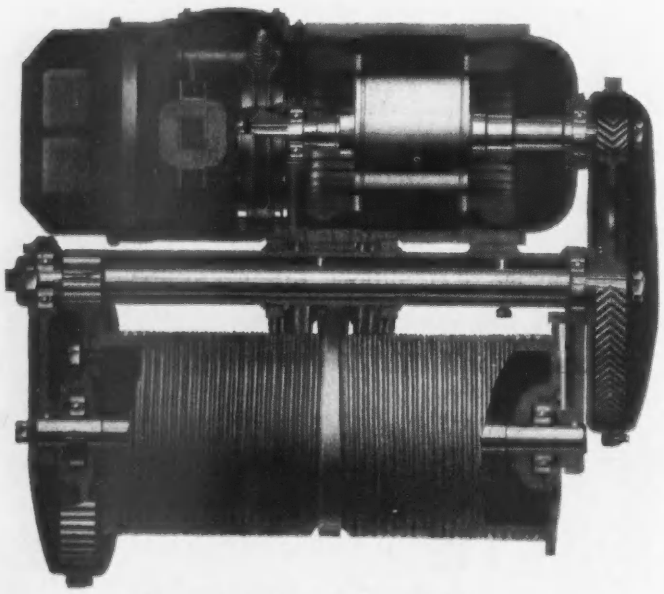

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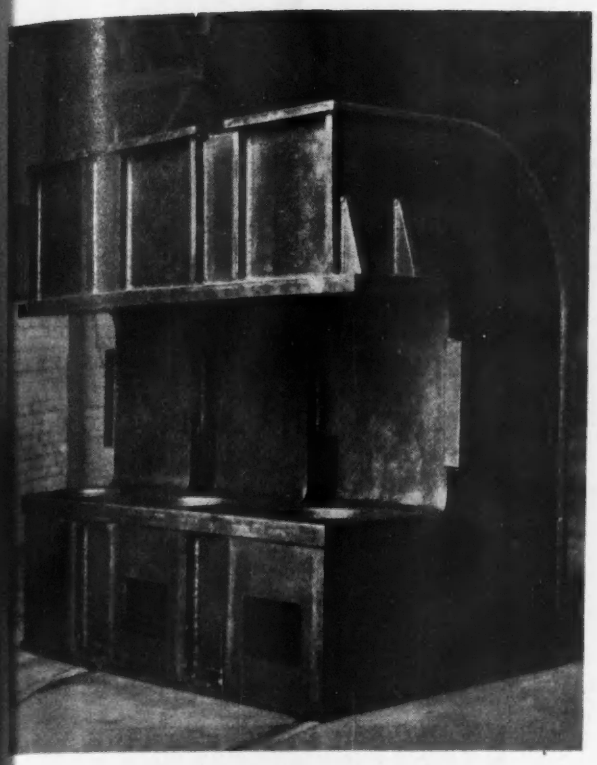

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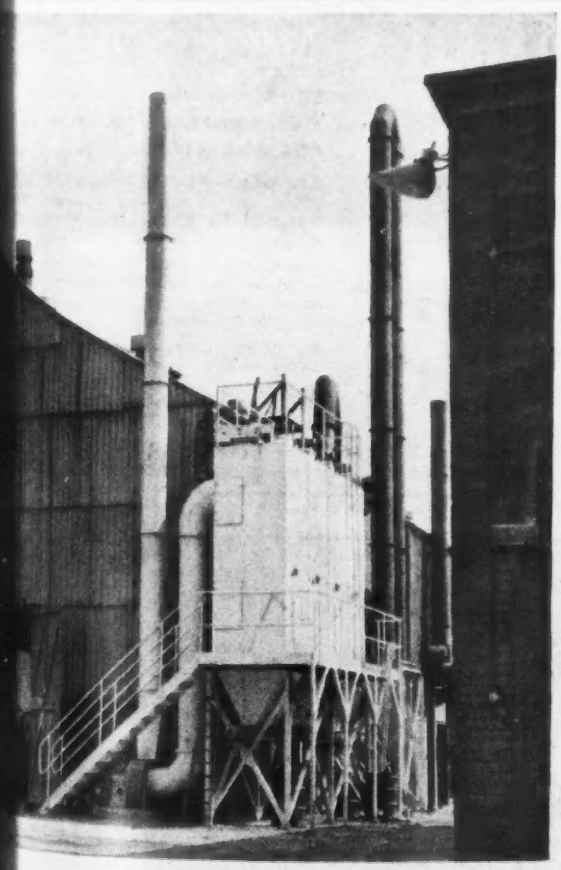

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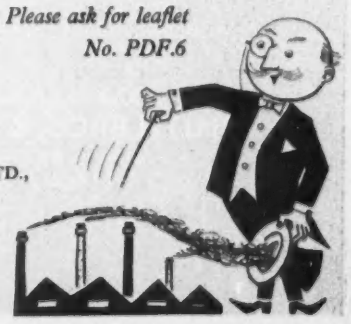

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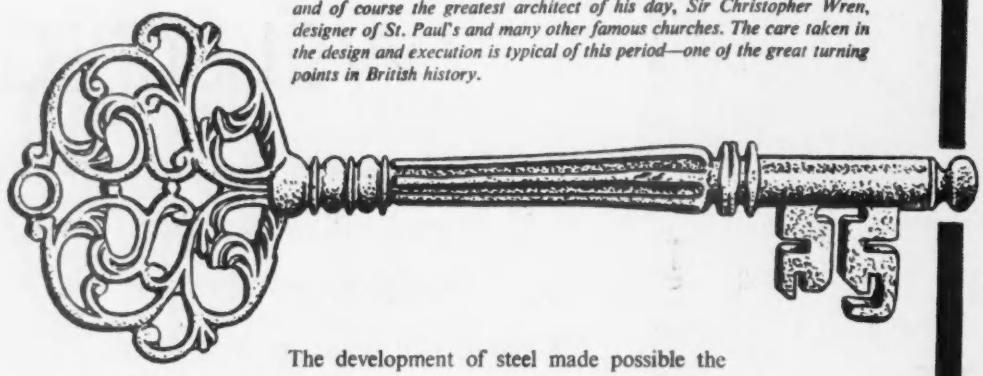
STEEL KEY TO INDUSTRY

No. 27

We illustrate No. 3 in this series of hand-wrought steel keys, made during the reign of Charles II. It does not leave much to the imagination looking at this key to conjure up some great events of the time such as the Reformation, The Plague, The Fire, 'Nell of Old Drury' and the diarist Samuel Pepys and of course the greatest architect of his day, Sir Christopher Wren, designer of St. Paul's and many other famous churches. The care taken in the design and execution is typical of this period—one of the great turning points in British history.



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Can you distinguish the difference between the Key shown in No. 25 and the one herewith illustrated? These two keys were very likely made by the same craftsman.

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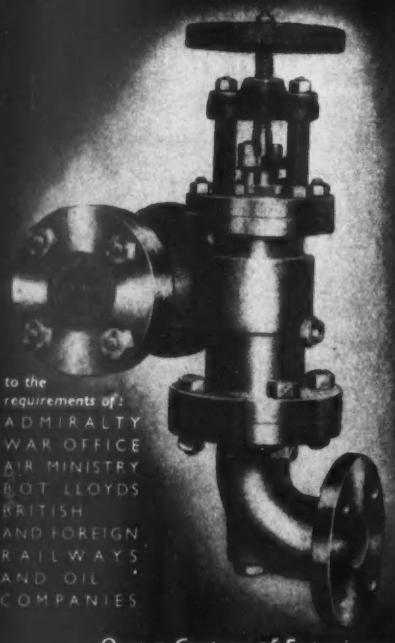

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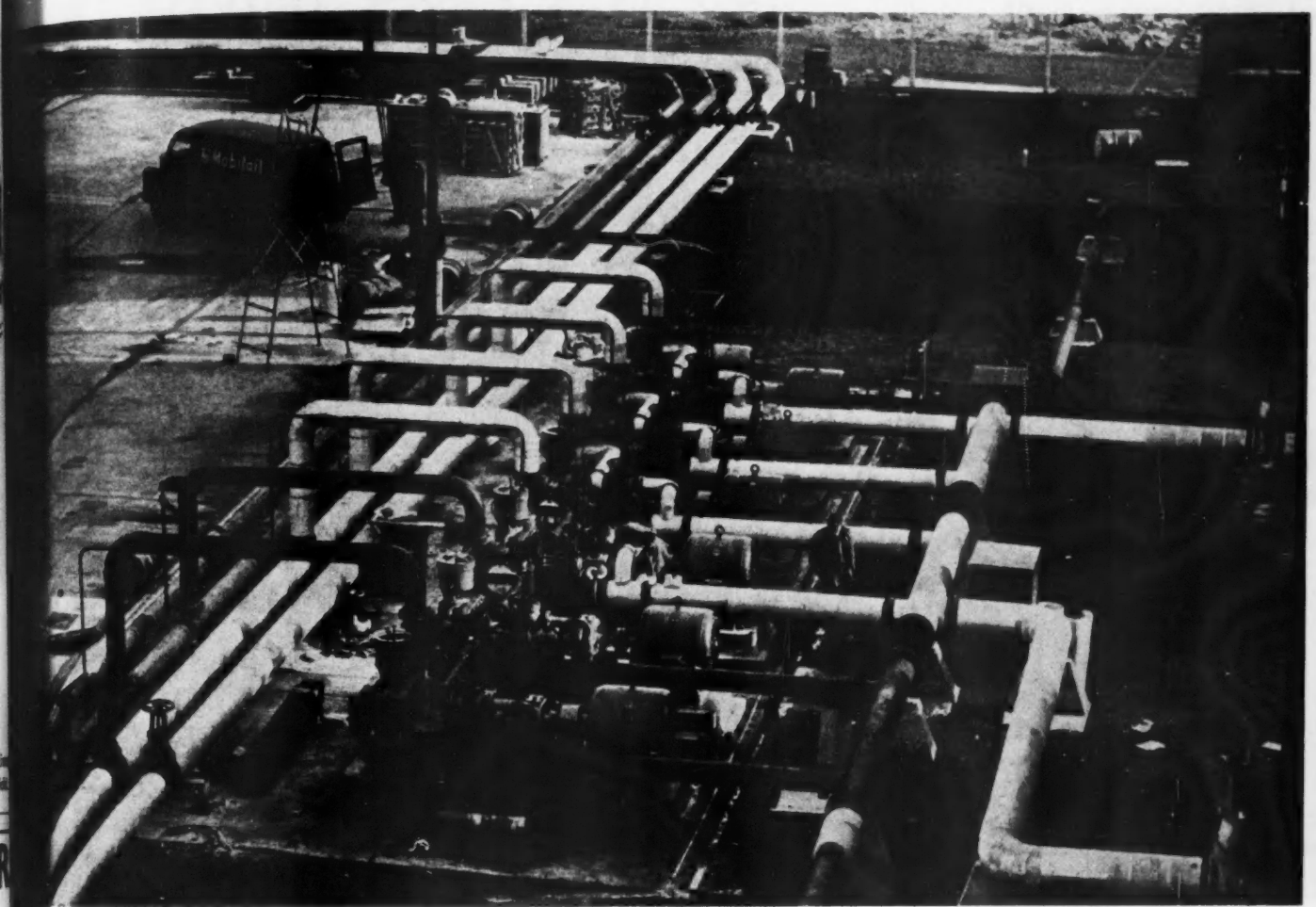

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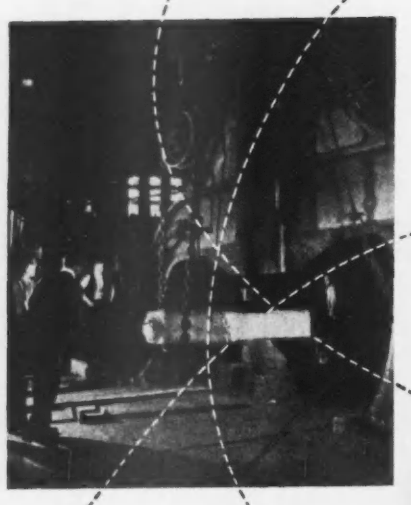

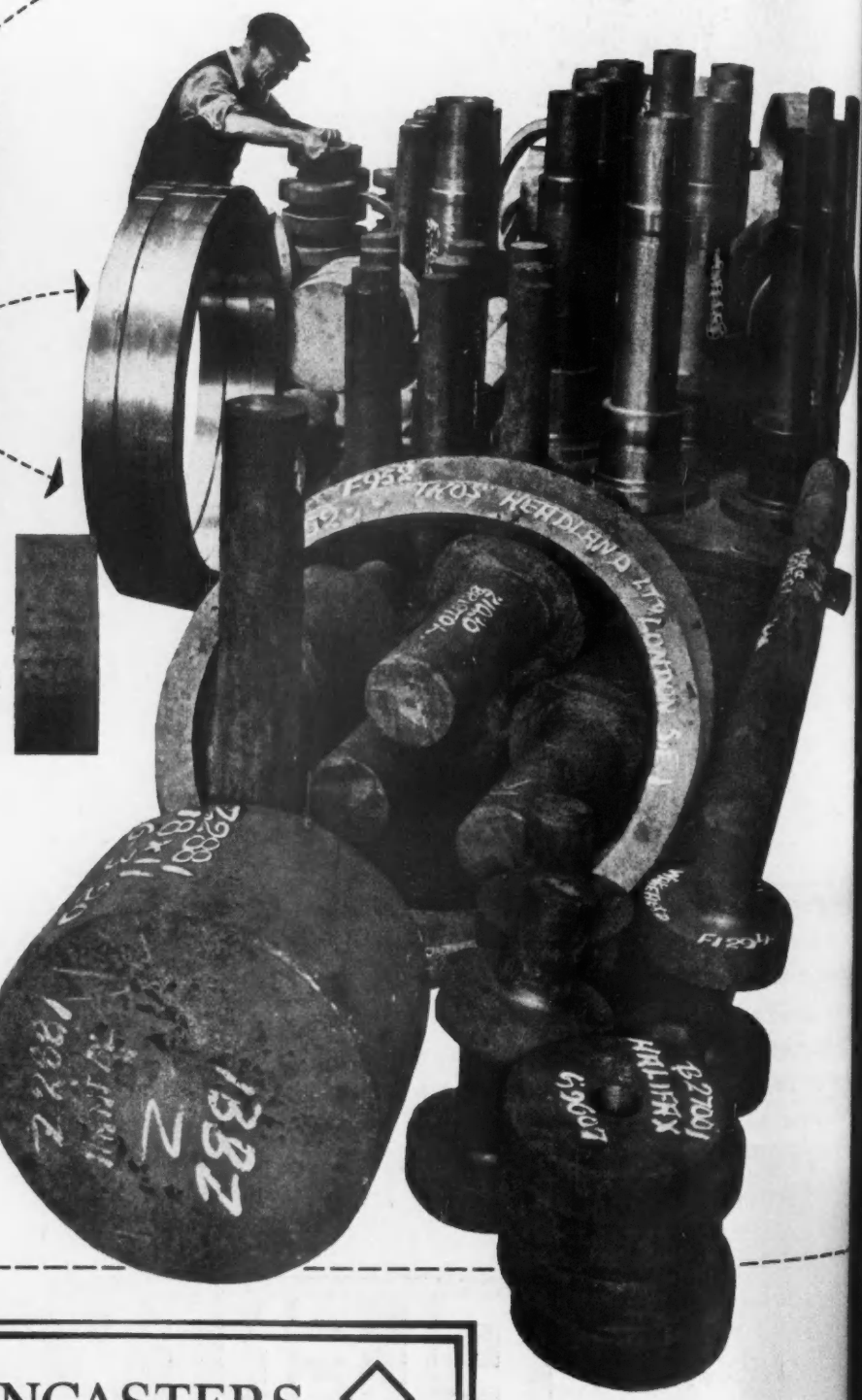

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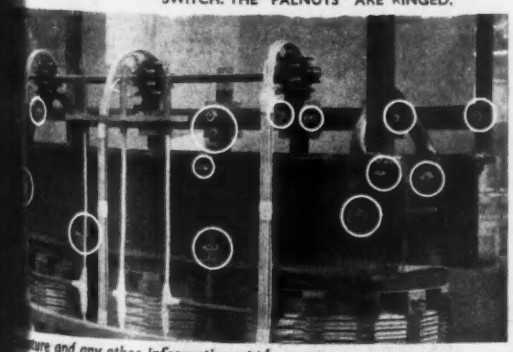

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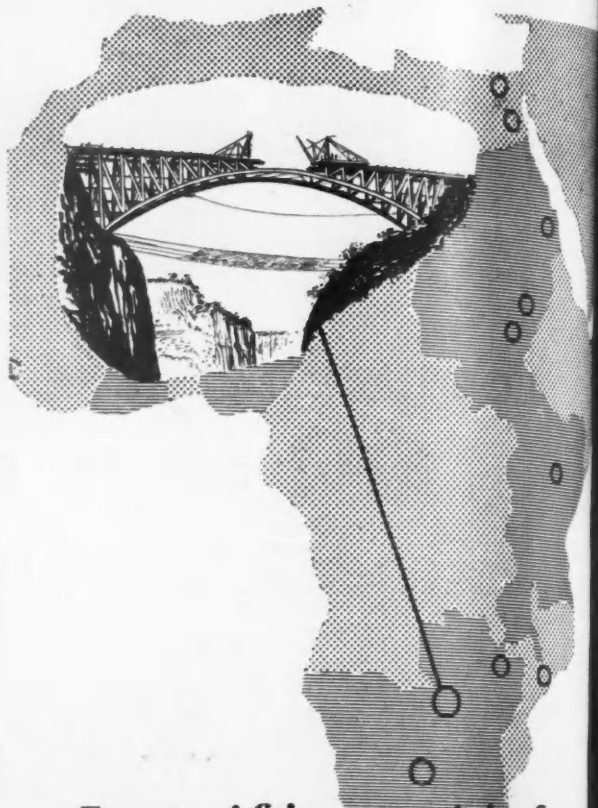

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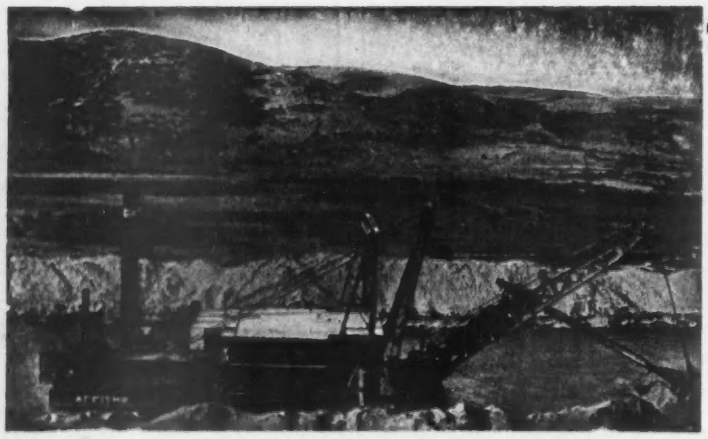

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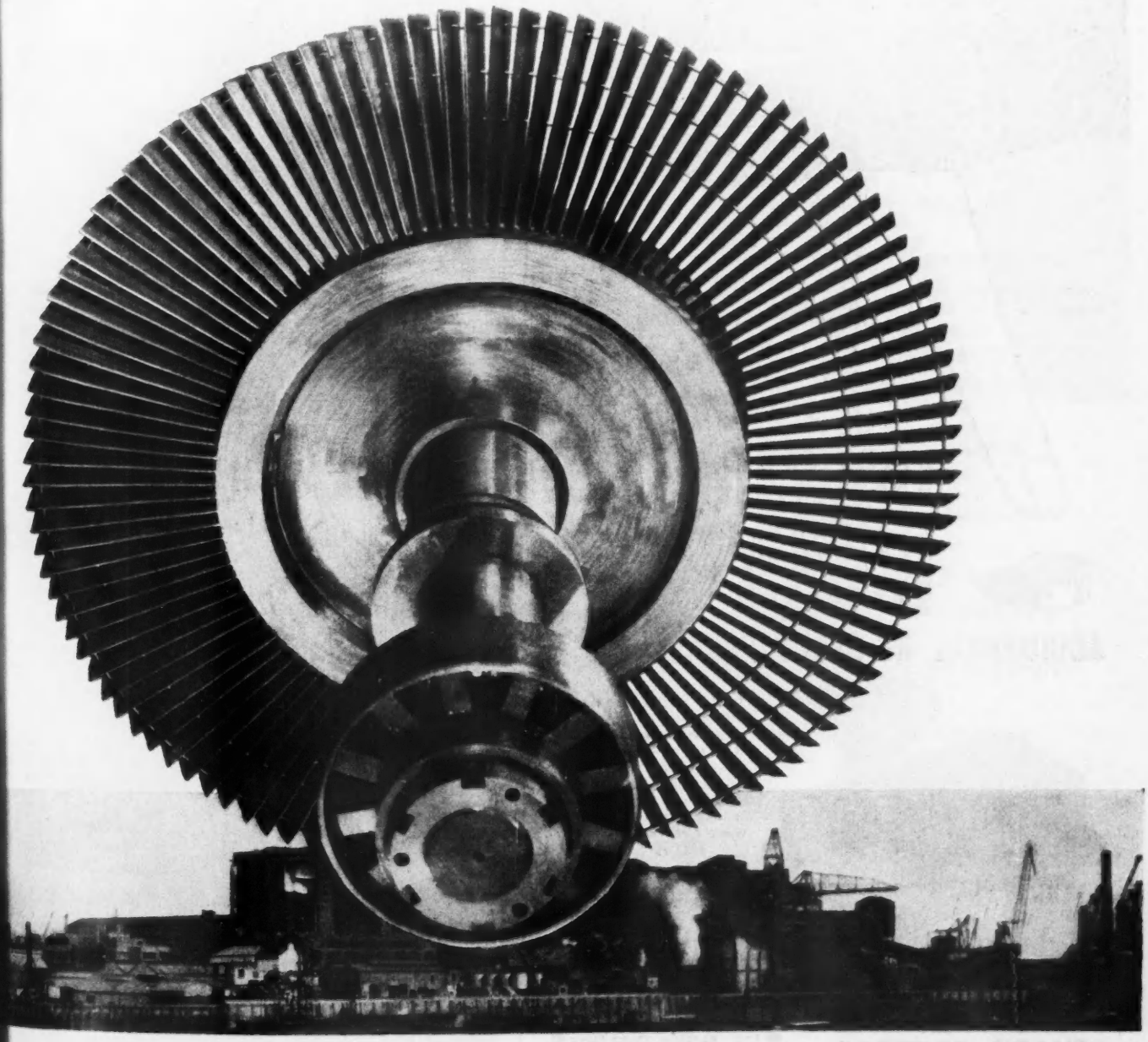

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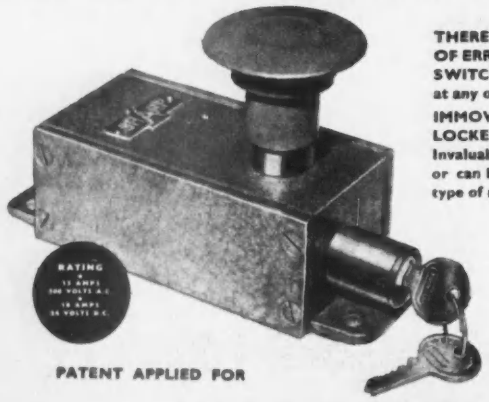

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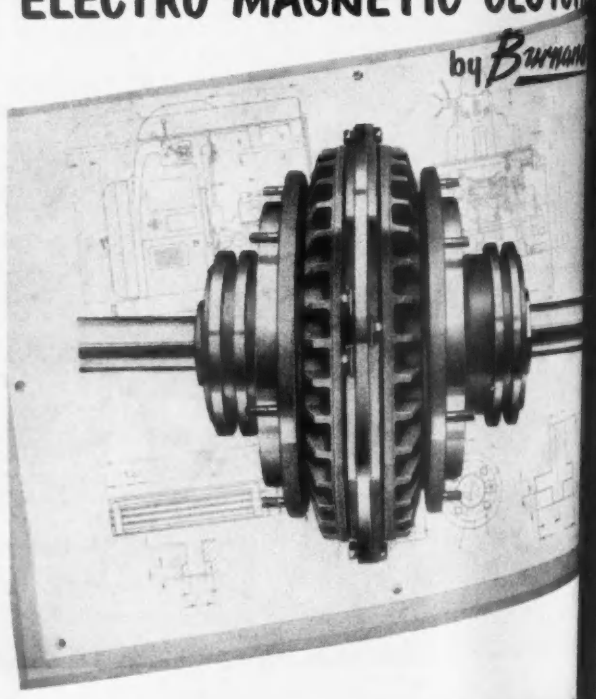

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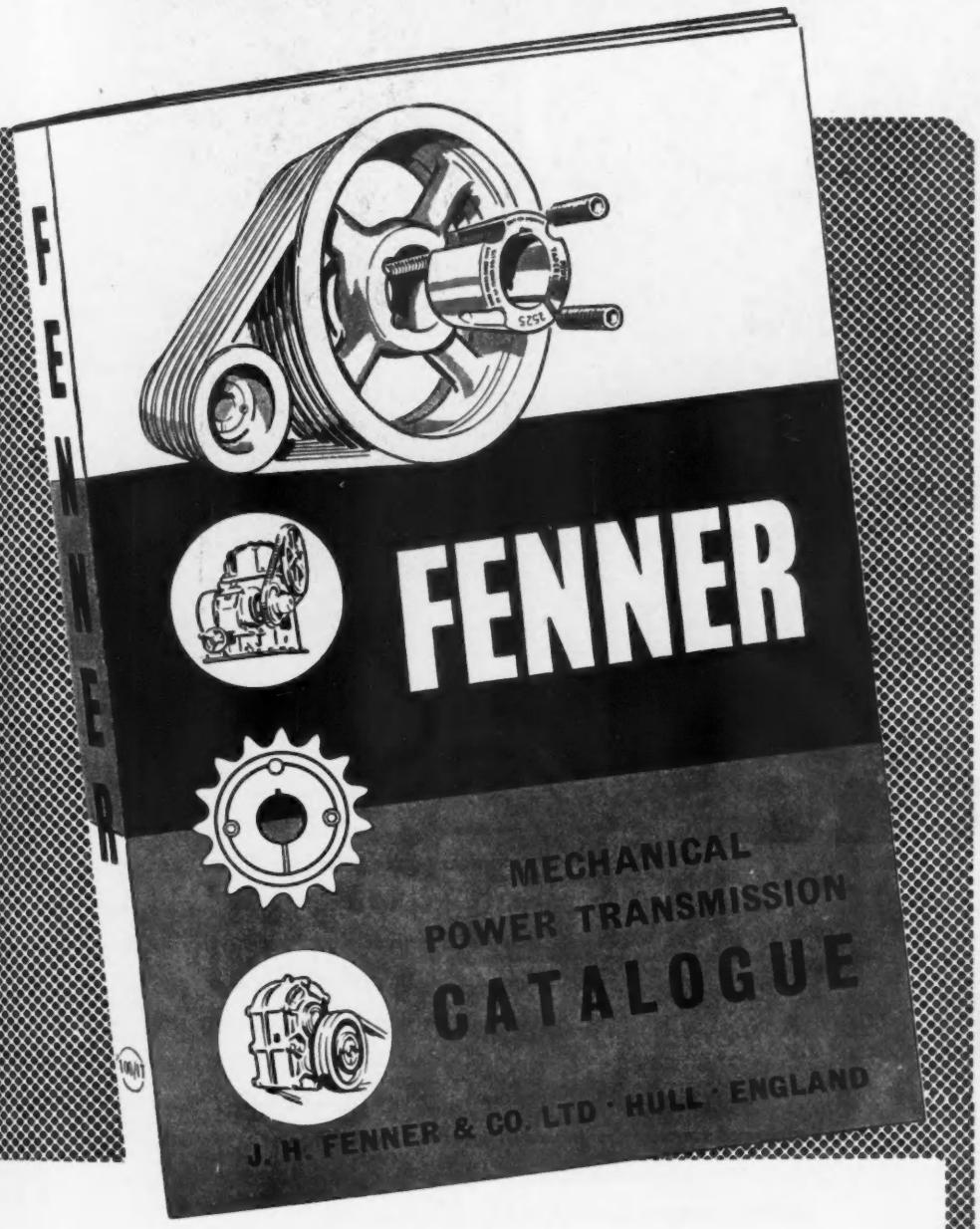

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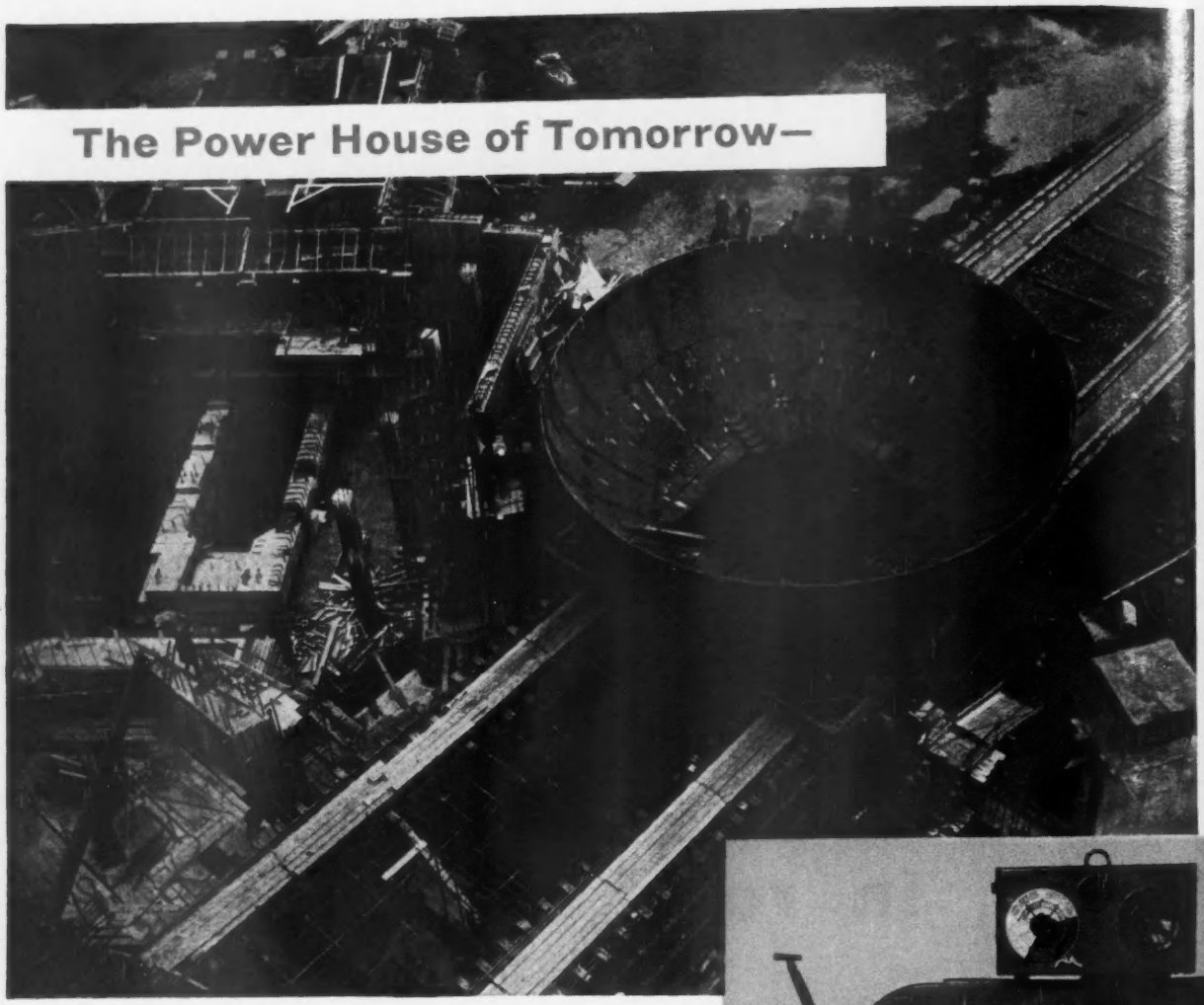
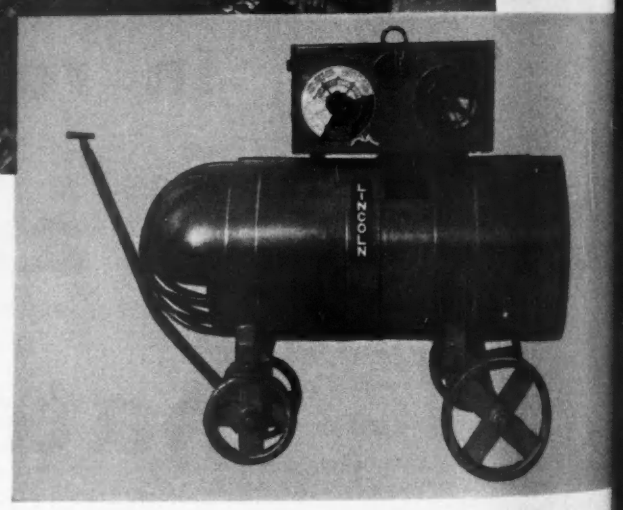
Birmingho Bristol, Leeds, Leicester, Liverpool, Manchester, Newcastle, Cardiff, Glasgow, Dublin, Belfast, Bulawayo, Johannesb g, Singapore, Vancouver.

Export Sales: 54 Grosvenor Street, London W.1

FIRST IN THE FIELD—AND STIL IN THE LE





BUILT WITH THE POWER UNIT OF TODAY

LINCOLN ELECTRIC COMPANY LIMITED, the largest manufacturers of D.C. Welding Equipment in the United Kingdom, proudly announce that they have been privileged to supply a large number of their SAE 300 amp and SAE 600 amp Motor Generators (to provide current for Class 1 pressure vessel welding) to Messrs. John Thompson (Wolverhampton) Limited, who are constructing the pressure vessels at the 275 MW Nuclear Power Station being built by the A.E.I-John Thompson Nuclear Energy Co. Ltd. for the Central Electricity Authority at Berkeley, Gloucestershire.

The Lincoln SAE 300 and SAE 600 Motor Generators are motor-driven welders with self-indicating dual continuous control and a selection of any type and size of arc for every job. The self protected motor permits sustained operation at a high current.

Ultimately 80 of these famous Lincoln Electric Company Limited's power units will be providing current for high class welding on the Berkeley Nuclear Power Station project.

For full details of the Lincoln Electric range of D.C. Generator units—from the S.A. 150 amp workshop 'Junior' to the SAE 900 amp for large Lincolnweld installations please write to:

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'SILENTBLOC' rubber-metal mountings are the accepted means of insulating almost anything from vibration—from small and delicate instruments to multi-ton drop-hammers. If you have a vibration problem, bring it to us as pioneers and far and away the leaders in the use of rubber in engineering. Technical information always available from *Silentbloc Limited, Manor Royal, Crawley, Sussex. Telephone: Crawley 2100.*

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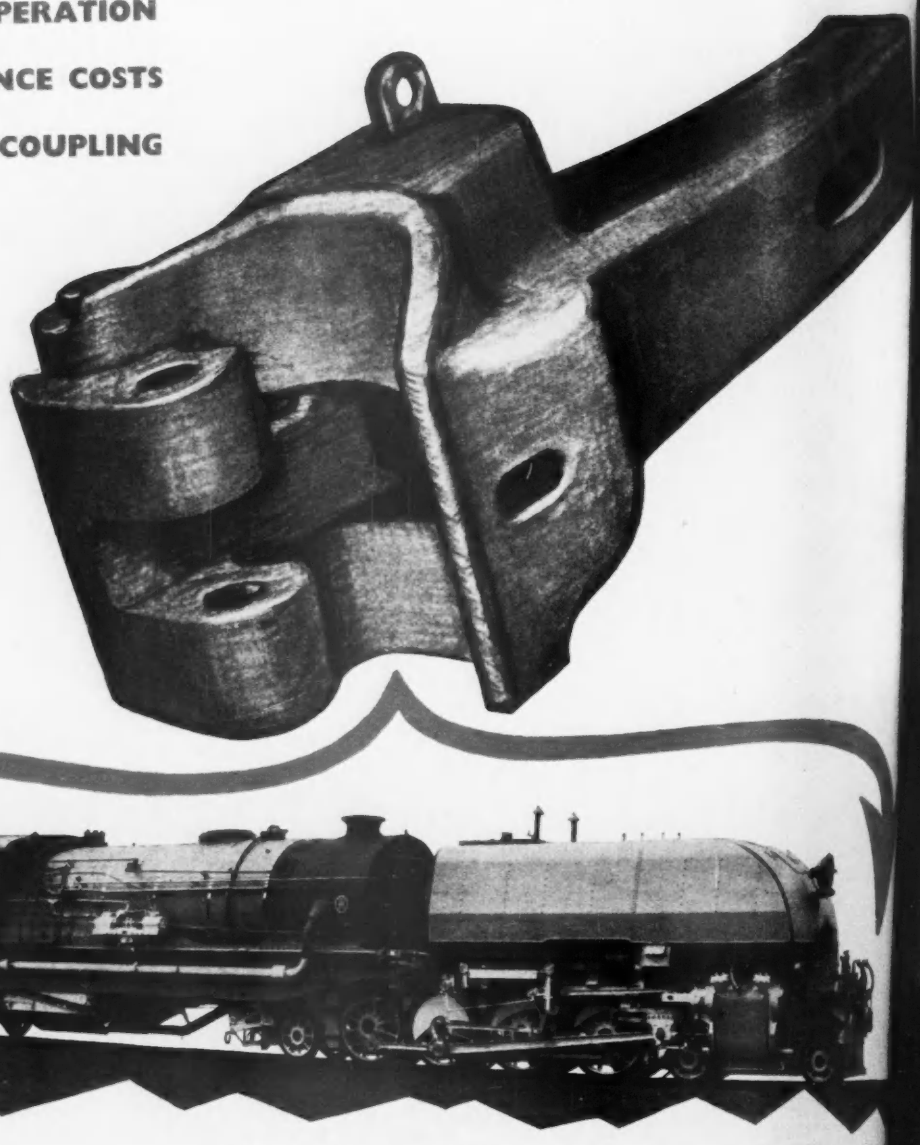
ANDRE RUBBER CO. LTD. — A SILENTBLOC COMPANY

Pioneers of Rubber in Engineering

TAS 5818

ESC automatic coupler

- SIMPLE IN OPERATION
- LOW MAINTENANCE COSTS
- SAFER and SPEEDIER COUPLING



Photograph of Rhodesia Railways 20th class Beyer-Garratt Locomotive—By courtesy of Beyer Peacock & Co., Ltd.

Outstanding in design, the E S C " Alliance " automatic coupler is standard equipment on many railways throughout the World.

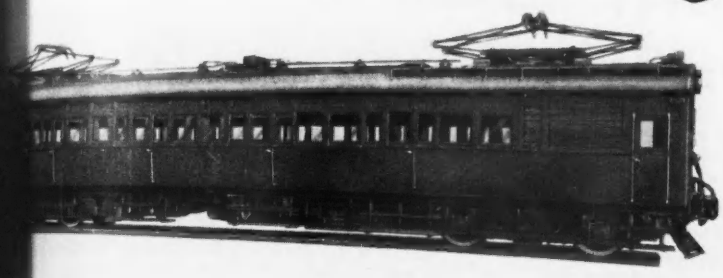
Made of a few parts of simple rugged design and embodying the latest improvements, this coupler meets all the requirements of up-to-date transportation systems which call for increased speeds, reduced maintenance costs and simplicity of operation.

ENGLISH STEEL CASTINGS CORPORATION LT

River Don Works, Sheffield.

A WHOLLY OWNED SUBSIDIARY OF ENGLISH STEEL CORPORATION LTD.

EXPERIENCE COUNTS!

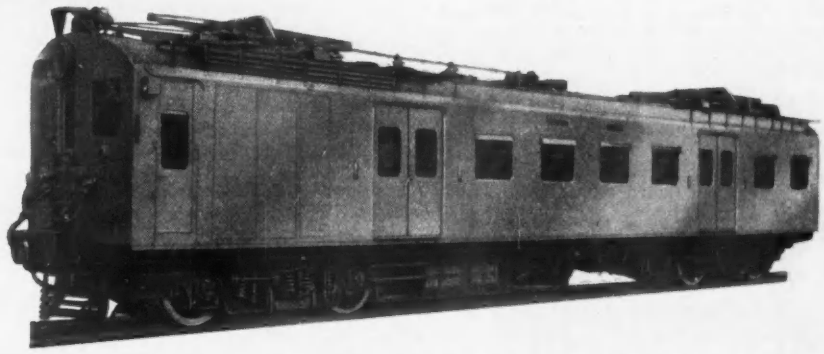


1936

3rd Class Motor Coach for the Reef Electrified Services of the SOUTH AFRICAN RAILWAYS.

Motor Coach for the Reef Services of the SOUTH RAILWAYS.

1958



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METROPOLITAN-CAMMELL CARRIAGE & WAGON CO. LTD
HEAD OFFICE: SALTLEY · BIRMINGHAM, 8
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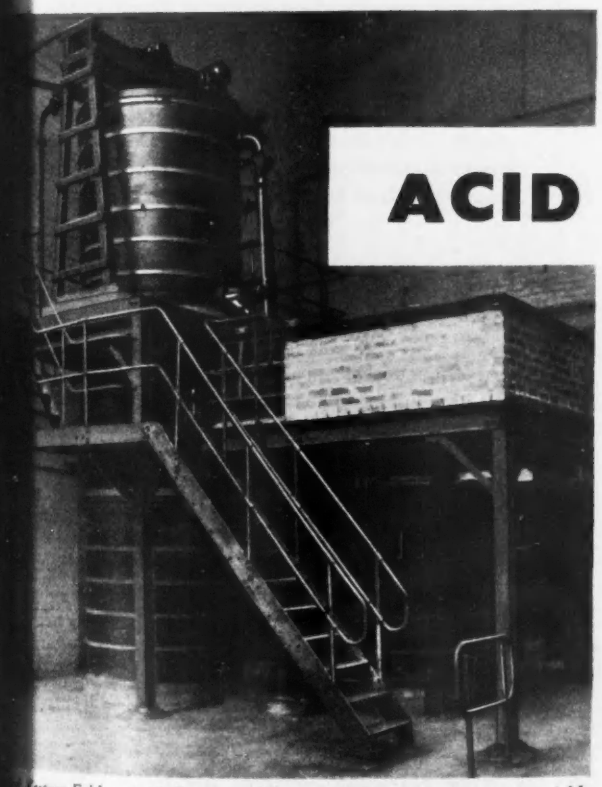


Kestner-Fakler Acid Recovery Plant used for recovering waste pickle in Iron and Steel Industry.

KESTNER-FAKLER

ACID RECOVERY PLANT

for your pickling plant

The advantages of Kestner-Fakler acid recovery plant are:

1. The Kestner-Fakler acid recovery plant can be operated by unskilled labour and requires no special attention.
2. It requires little maintenance as the number of parts are limited.
3. It is manufactured in the well-known Kestner plastic constructional material Keebush, completely inert to the action of sulphuric acid pickling liquor.
4. Pays for itself within a few years and the initial installation is low in first cost.
5. Gives very uniform working and avoids over or under pickling.
6. Enables all acid normally thrown to drain to be recovered.
7. Overcomes effluent disposal problems and, as such, is favoured by Local Authorities.

The Kestner-Fakler acid recovery plant can be fitted to all types of pickling plant. Send for full details to:

Kestner Evaporator & Engineering Co. Ltd.
5 GROSVENOR GARDENS, LONDON, S.W.1

Kestner
THE CHEMICAL ENGINEERS

CENTRAL ELECTRICITY GENERATING BOA

TARIFF FOR BULK SUPPLIES TO AREA BOARDS

fixed by the Central Electricity Generating Board (the Generating Board) pursuant to section 37 (1) of the Electricity Ac
for the year ending 31st March, 1959.

KILOWATT CHARGE

£6 (six pounds) for each kilowatt of simultaneous maximum demand where "simultaneous maximum demand" means either

(*a*) twice the largest number of kilowatt-hours supplied by the Generating Board to the Area Board during any half-hour between 7 a.m. and 7 p.m. on any Monday, Tuesday, Wednesday, Thursday or Friday or between 7 a.m. and 12 noon on any Saturday in the year.

or, if the sum of the simultaneous maximum demands (ascertained according to paragraph (*a*) above) of each Area Board and the chargeable maximum demands in the year of the other direct consumers of the Generating Board differs from 20,840,000 kilowatts by more than one per cent.

(*b*) the simultaneous maximum demand ascertained according to paragraph (*a*) above multiplied by 20,840,000 and divided by the number of kilowatts in the said sum mentioned above.

RUNNING CHARGE

0·47d. (decimal four seven of a penny) for each kilowatt-hour supplied during the year, this charge to be increased or reduced by 0·0006d. (decimal nought nought nought six of a penny) for each penny (a halfpenny or any greater part of a penny being treated as a penny) by which the fuel cost per ton in the year shall be above or below 60s. (sixty shillings).

For this purpose :

(i) "**Fuel cost per ton**" in any period shall be either

(*a*) the quotient produced by dividing the aggregate of the product of the **Area fuel cost per ton** in the period and the **number of kilowatt-hours supplied from generation in the Area** in the period and the product of **the residual cost per ton** in the period and **the number of kilowatt-hours imported into the Area** if any in the period by **the number of kilowatt-hours supplied in the Area** in the period ; or

(*b*) **the Area fuel cost per ton ;**
whichever is the less.

(ii) "**The Area**" means the Area of the Area Board taking the supply.

(iii) "**The Area fuel cost per ton**" in any period shall be determined as follows : the total **cost of fuel consumed** in the period at all Generating Board's stations in **the Area** shall be divided by the total number of tons **of fuel** so consumed and the cost per ton so obtained shall be multiplied by 11,000 and divided by the average gross thermal value of **fuel** so consumed expressed in British thermal units per pound.

(iv) "**Fuel**" shall mean coal, coke and oil fuel but shall not include atomic fuels.

(v) "**The cost of fuel consumed**" shall mean the sums
for **fuel** consumed plus the cost of any transport,
preparation or treatment incurred in connection
delivery of the **fuel** to boiler hoppers or furnaces and
nection with the disposal of the products or residues of
tion, together with the proper proportion of salaries
and any contributions for pensions, superannuation and
of officers and servants attributable thereto and the
any rebate allowed by the suppliers from the price of
oil delivered at the Generating Board's stations, suc
being attributable only to a specific quantity of heavy
delivered, less any sums received from the sale of any
or residues of combustion.

(vi) "**The number of kilowatt-hours supplied from g
in the Area**" in any period means the number of
hours (being kilowatt-hours generated by the comb
fuel) sent out from all the stations of the Generating
the Area in the period or **the number of kilowa
supplied in the Area** in the period whichever is the

(vii) "**The number of kilowatt-hours supplied** in the
any period shall mean the number of kilowatt-hour
in the period by the Generating Board to the
Board and to other consumers in **the Area**.

(viii) "**The number of kilowatt-hours imported into t**
means the amount if any by which **the number of
hours supplied in the Area** exceeds **the number of
hours supplied from generation in the Area**.

(ix) "**The residual cost per ton**" in any period sha
aggregate of—

(A) The quotient produced by dividing the amount
the **national fuel cost per ton** in the period
by the aggregate of **the number of kilowatt-hour
in the Area** of each Area Board in the period
aggregate of the respective products in the ca
Area Board of (*a*) **the Area fuel cost per ton**
and (*b*) **the number of kilowatt-hours sup
generation in the Area** in the period, by the
of the **number** of **kilowatt-hours importe
Area** of each Area Board in the period ; and

(B) the sum of 6s. (six shillings).

(x) "**The National fuel cost per ton**" in any per
determined as follows : **the total cost of fuel**
in the period at all the Generating Board's statio
divided by the total number of tons of **fuel** so co
the cost per ton so obtained shall be multiplied by
divided by the average gross thermal value of the
sumed expressed in British thermal units per pound.

Of all the devices men have used to harness air, none is so effective as A·I·D EQUIPMENT

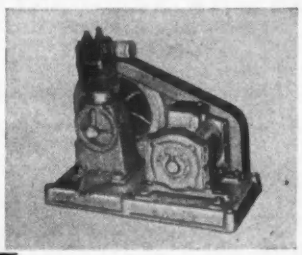
Bellows are one of man's oldest methods of compressing and directing air. The pair illustrated here are a beautiful example of the silversmiths art and were given to Nell Gwynn by King Charles II.

AID spray equipment will apply your finishes or coatings faster, easier and better. Now that's quite a bold claim to make, but having wrestled with the problem of applying practically every imaginable type of fluid to so many surfaces for so many years, we know that our practical experience will give you better finishes in shorter time with resultant economy.

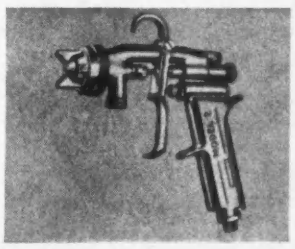
AID equipment, from guns, through compressors and to complete installations, is the result of shirt-sleeve knowledge acquired where it matters most — in the workshop.

The guns — and the range covers every field — are designed round the operator. They handle easier, clean easier, give 100% atomisation and speed up production. The compressors too, precision jobs specially rated for the job required, are built for longer life and unvarying delivery. Spray booths and complete installations? Well, why not have a chat with our technicians — no obligation will be incurred of course.

Model 10/14B. *Single stage semi-automatic stationary compressor — supplied complete with air receiver*



Model 2. *The famous spray gun that excels in every significant detail*



AID

SELLING STARTS AT THE FINISH

AIR INDUSTRIAL DEVELOPMENTS LTD

Aidspray Works · Shenstone · Nr. Lichfield · Staffs · England · Phone: Shenstone 341/5

Grams: Aidspray, Shenstone · Canadian Office: 4 Lailey Crescent, Willowdale, Ontario. BA 1.2677

Brochure on High Strength Bolting, available on request.

Samuel Marsden & SON LTD

London Rep: W. Kelway Bamber & Co. Limited, 9 Victoria Street, S.W.1. Telephone: Abbey 6860

N. E. Coast: Fasteners Ltd, 2 Hall St. Barnard Castle, County Durham. Telephone: Barnard Castle 3172

dm SM.38

SHEET METAL WORK

SPECIALISTS IN FABRICATED MACHINERY

GENERAL SHEET METAL WORKERS

Brake Press Capacity 8 ft. × $\frac{5}{16}$ in.

DIFFICULT JOBS OUR SPECIALITY

SHEET METAL SHAPES LTD.
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extra strength

The patented thrust washer is a Cheney Worm Drive Clip exclusive. It permits the use of a larger diameter screw, giving a deeper, more positive thread engagement with a never-relaxing grip to withstand greater torque. And yet the Cheney Worm Drive Clip costs no more than a conventional clip.

at no extra cost

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Trade Enquiries to:
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Rigid Stem

Transmitting

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'Phone —— SOU 0858

WE REPAIR ALL MAKES OF MERCURY IN STEEL THERMOMETERS & RECORDERS

ON BALLYHOO, BARGAINS AND BULK

A 3680 gallon Mild Steel ... ling unit (unpainted ...

Building Road Tanks isn't everyone's job and the bargain basement is no place to look for them. Operators find that to be wrong on this is to leave them holding a big ' bulk ' baby.

Butterfields have been building Road Tanks as long as anyone and much longer than most people . . . Butterfield Road Tanks have never pretended to be cheap but have often proved, through years of service, to be ***genuine*** bargains, on the principle that what really pays is not promise but performance.

Butterfield

ROAD TANKS

STAINLESS STEEL · MILD STEEL · ALUMINIUM · NICKEL · MONEL

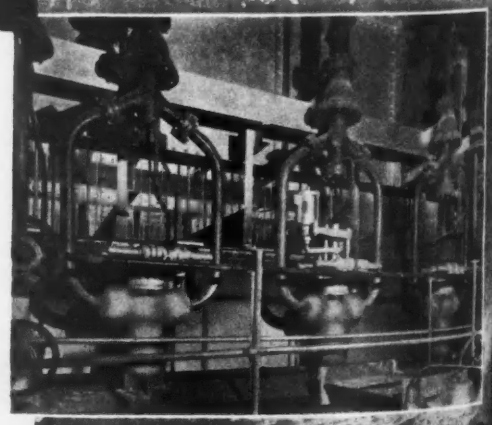
For ease of reference please mark all enquiries as follows: E/14/3

W. P. Butterfield Ltd. P.O. Box 38, Shipley, Yorkshire Telephone : 52244 (8 lines)
Branches LONDON Telephone HOLborn 2455 (4 lines) BIRMINGHAM Telephone EAS 0871 & EAS 2241
BRISTOL Telephone 27905 LIVERPOOL Telephone Central 0829 MANCHESTER Telephone Blackfriars 9417 NEWCASTLE-ON-TYNE Telephone 23823
GLASGOW Telephone Central 7696 BELFAST Telephone 57343 DUBLIN Telephone 73475 & 79745

100 OVER 900 psi !

Of the power stations now operating at over 900 psi more than one hundred are equipped with

HOPKINSONS' BOILER MOUNTINGS



HOPKINSONS LIMITED · HUDDERSFIELD

LONDON OFFICE 34 NORFOLK STREET · STRAND W.C.2

CLASSIFIED ADVERTISEMENTS

...CIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL ...NTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS ...SSES and PREMISES · TENDERS

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

...ate. 4/- per line of approximately 6 words. Minimum 16/-.

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

... 48/- per single column inch and *pro rata*. 12 lines to 1 inch. ...are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page ...umn inches) and upwards, *e.g.*, ¼-page £25 10s. ½-page £48. Full page £90.

Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, *e.g.*, ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

...d Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

... and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). ...ter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

...x Number. 2/-, which includes forwarding of replies.

..., "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon ...or publication on following Friday. All advertisements three days earlier if proofs are required.

...ments for publication should be addressed to:— **Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

...LIC APPOINTMENTS

...UBLIC OF THE SUDAN

...M TECHNICAL INSTITUTE

LECTURERS

...y of Education invites applications ... qualified candidates for the post of ... in the following Departments in the ...nical Institute: (a) Civil Engineer- ...hanical and Electrical Engineering; ... Qualification for (a) and (b) is a ... Mechanical or Electrical Engineer- ...al equivalent, e.g. A.M.I.Mech.E., A.M.I.C.E., A.R.I.B.A., &c. Teaching ... a similar appointment would be an ...er (c) a Degree in Economics or ...uivalent qualification in Accountancy ... Minimum age 25 years. Successful ...s (a) and (b) will be required to teach ...e to Higher National Certificate and ...uired to supervise certain Workshop ...y activities. Candidates for (c) will ...each their subjects. Accountancy or ... to professional standards.

... will be on Short Term Contract, ... a period up to five years. Salary ...m £S1075 to £S1675 per annum for ...S1075 to £S1975 for Senior Lecturers. ... into the scale will be determined by ...ons and experience. A cost-of-living ...ich is reviewed every two months is ...outfit allowance of £S50 is payable on ...

... preferably on a postcard, for applica- ...d further information, to the Sudan ...onnel Section, Cleveland Row St. ...don, S.W.1, quoting "Lecturers ...ing date, 31st March, 1958. E6466

...EMOUTH EDUCATION COMMITTEE

...OUTH MUNICIPAL COLLEGE ...NOLOGY AND COMMERCE

...ANICAL ENGINEERING DEPARTMENT

LECTURER

... required, as soon as possible, to ...n Engineering Subjects to the standard ... and the Final C. and G. Course in ... Engineering, and to be responsible ...sation of the production engineering ...elopment of the machine fitting and ...n the Department. Applicants should ...ty Degree or equivalent qualification. ...eaching experience essential. Salary ...urnham Technical Scale, 1956, viz. ...o £1350 p.a.

...orms, returnable as soon as possible, ... Smedley, Chief Education Officer, ...mouth. E6468

...VERSITY OF LIVERPOOL

...T OF CIVIL ENGINEERING

LECTURER

... are invited for the post of LEC- ... Department of Civil Engineering. ...ary within the range £900–£1250 per ...g to qualifications and experience. ...stating age, academic qualifications ... together with the names of three ... be received not later than 29th ... the Registrar, from whom further ...e conditions of appointment may be ... E6377

...WICH POLYTECHNIC ...LONDON, S.E.18

...GRADE B IN MECHANICAL ...ENGINEERING

...ovided for ASSISTANT GRADE B ...CAL ENGINEERING; should have ... Certificate or similar qualification. ... £650–£1200, commencing salary ...ualifications and experience, plus ...ce of £36 to £48. ...d application form from Clerk to ... returned by 28th March, 1958. E6471

PUBLIC APPOINTMENTS

UNIVERSITY OF EDINBURGH

DEPARTMENT OF ENGINEERING

LECTURER

Applications are invited for the post of LECTURER in the Department of Engineering. The salary scale is £900 by £50 to £1100; Bar: £1150 by £50 to £1350 by £75 to £1650 per annum, with placement according to qualifications and experience, and with superannuation benefit and family allowance where applicable.

Candidates should possess an Honours Degree in Engineering, together with industrial, teaching or research experience. The duties of the appointment will be confined to the Civil-Mechanical teaching of the Department.

The successful candidate will be expected to take up duty as soon as convenient.

Further particulars may be obtained from the undersigned, with whom applications, giving the names of two referees, should be lodged not later than 9th April, 1958.

CHARLES H. STEWART,
Secretary to the University.
E6500

HUDDERSFIELD COLLEGE OF TECHNOLOGY

Principal: Dr. W. E. SCOTT, M.B.E.

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

GRADE "B" ASSISTANT

Required as soon as possible, Grade "B" ASSISTANT, to Teach Machine Design and Mechanics of Machines. Good industrial, and preferably some teaching, experience desirable.

The salary (Burnham Scale) rises to a maximum of £1025, plus allowances for Graduate status (£75 or £125) and training (£25 to £75). The commencing salary will depend upon qualifications and experience and may include up to 12 increments in respect of approved service in industry.

Further particulars and forms of application, which must be returned as soon as possible, obtainable from the Principal, College of Technology, Queen Street South, Huddersfield.

H. GRAY,
Chief Education Officer.
7th March, 1958. E6504

WELSH COLLEGE OF ADVANCED TECHNOLOGY

CATHAYS PARK, CARDIFF

APPOINTMENT

Applications are invited for the post of HEAD OF THE DEPARTMENT OF ENGINEERING. Applicants should be mechanical engineers and must have good teaching, industrial and/or research experience.

The salary will be in accordance with Grade V of the Burnham Report, i.e. £1900 by £50 to £2050. The post will be vacant from 1st September, consequent upon the appointment of the present holder to a Principalship.

Forms of application, together with further particulars, may be obtained from the Principal and should be returned to him as soon as possible.

ROBERT E. PRESSWOOD,
Clerk to the Governors.
March, 1958. E6476

UNIVERSITY COLLEGE OF SWANSEA

LECTURESHIP IN CIVIL OR MECHANICAL ENGINEERING

Applications are invited for a LECTURESHIP IN CIVIL OR MECHANICAL ENGINEERING. Salary on the scale £900–£1650 per annum. Commencing salary can be at any point on the scale, according to qualifications and experience. Membership of F.S.S.U. and children's allowance scheme.

Further particulars may be obtained from the Registrar, University College, Singleton Park, Swansea, to whom applications (six copies) must be sent by Thursday, April 10, 1958. E6395

PUBLIC APPOINTMENTS

HAMPSHIRE EDUCATION COMMITTEE

FARNBOROUGH TECHNICAL COLLEGE

Principal: Mr. R. D. PEGGS, O.B.E., M.A., M.I.Mech.E., F.R.Ae.S.

LECTURERS

Applications are invited for the following posts from September, 1958:—

ASSISTANT LECTURER (GRADE B) IN MECHANICAL ENGINEERING.
ASSISTANT LECTURER (GRADE B) IN ELECTRICAL ENGINEERING.
ASSISTANT LECTURER (GRADE B) IN APPLIED PHYSICS.

Successful candidates will be required to assist in courses for O.N.C. in Mechanical Engineering, Electrical Engineering, and in Applied Physics, which will be developed to include H.N.C. courses.

Industrial experience is desirable in each case.

The salaries for all posts are in accordance with the Burnham Scale for Teachers in Technical Colleges: Assistants Grade B, £650 by £25 to £1025, and the usual allowances for training, qualifications and industrial experience, e.g. £125 for a good Honours Degree.

Further particulars and application forms may be obtained from The Principal, Farnborough Technical College, Boundary Road, Farnborough, Hants, to whom they should be returned as soon as possible.

R. M. MARSH,
County Education Officer.
The Castle,
Winchester. E6513

SURREY EDUCATION COMMITTEE

KINGSTON TECHNICAL COLLEGE, FASSETT ROAD, KINGSTON-UPON-THAMES

APPOINTMENTS

Required for 1st September, 1958, ENGINEERING DEPARTMENT:—

3 LECTURERS in MECHANICAL ENGINEERING (able to offer to a high level one or more of the following subjects: Aeronautics, Strength of Materials, Mechanics of Fluids, Theory of Machines, Theory of Structures).
LECTURER in ELECTRICAL ENGINEERING.
LECTURER IN MATHEMATICS.
ASSISTANT Grade B, in MECHANICAL ENGINEERING.
ASSISTANT, Grade B, in MATHEMATICS.

Candidates for the Lecturer posts must be Graduates, or hold equivalent professional qualifications. Appropriate experience in industry and in teaching required, and research experience will be a recommendation.

Salary scales: Lecturer (Men), £1200 by £30 to £1350 per annum; Assistant. Grade B (Men), £650 by £25 to £1025, with appropriate allowances for Degree, training and experience. London Allowance payable.

Further particulars and application form on receipt of stamped, addressed envelope, from Principal, to be returned by 11th April. E6502

WILTSHIRE EDUCATION COMMITTEE

APPOINTMENTS

SALISBURY AND SOUTH WILTS COLLEGE OF FURTHER EDUCATION

ASSISTANT GRADE "B" to teach Engineering Drawing, &c., to O.N.C. level. Post vacant from 14th April, 1958.

ASSISTANT GRADE "A" to teach Motor Vehicle subjects and Machine Shop Engineering; 1st September, 1958.

Forms and further details from the Principal, Grosvenor House, Churchfields, Salisbury.

TROWBRIDGE COLLEGE OF FURTHER EDUCATION

HEAD OF ENGINEERING DEPARTMENT, GRADE I, required from September, 1958. Must be University Graduate or Member of one of the Professional Institutions. Technical College experience essential. Industrial experience an advantage.

ASSISTANT GRADE "A," to teach Mathematics, Science and Engineering Drawing, but ability to teach Radio Service Work very desirable.

E6506

PUBLIC APPOINTMENTS

MIDDLESEX COUNTY COUNCIL EDUCATION COMMITTEE

WILLESDEN TECHNICAL COLLEGE DENZIL ROAD, WILLESDEN, N.W.10

LECTURERS

Required, for 1st September, 1958:

(a) LECTURER IN HEAVY ELECTRICAL ENGINEERING.
(b) LECTURER IN LIGHT ELECTRICAL ENGINEERING.
(c) LECTURER IN PRODUCTION ENGINEERING.
(d) LECTURER IN MATHEMATICS.

Applicants should possess a University Degree or its equivalent and applicants for posts (a), (b) and (c) must have had good industrial experience.

Salary in accordance with the Burnham (Technical) Report, 1956, i.e. £1200 by £30 to £1350, plus London allowance.

Application forms (stamped, addressed, foolscap envelope) from the Clerk to the Governing Body, Education Office, 163, Willesden Lane, N.W.6, to whom completed forms should be returned within 14 days of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
Secretary to the
E6508 Education Committee.

UNIVERSITY OF ADELAIDE, AUSTRALIA

LECTURER IN ELECTRICAL ENGINEERING

Applications are invited for appointment as LECTURER IN ELECTRICAL ENGINEERING. Preference will be given to a candidate strong in Mathematics and Physics, and with some experience in electronics design and laboratory work.

Salary scale: £A1420 by £A90 to £A2050, with superannuation on the F.S.S.U. basis.

Copies of the general conditions of appointment of Lecturers in the University may be had on application to the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1, or to the Registrar. Any further information desired will be supplied on request.

Applications, in duplicate and giving the information listed in the general conditions of appointment, should reach the Registrar, The University of Adelaide, Adelaide, South Australia, not later than April 30, 1958. E6507

KENT EDUCATION COMMITTEE

NORTH-WEST KENT COLLEGE OF TECHNOLOGY

MECHANICAL ENGINEERING DEPARTMENT

LECTURERS

Two LECTURERS required. New well-equipped premises will be opened this September, and due to the transfer of all advanced work in the area to this College, Lecturers are required to specialise in any Mechanical Engineering subject, according to their qualifications, to Higher National Certificate standard Salary in accordance with the Burnham Technical Scale (at present £1200 by £30 to £1350).

Application forms may be obtained from the Principal at the College, Miskin Road, Dartford, Kent. E6517

UNIVERSITY OF KHARTOUM

CHAIR OF CIVIL ENGINEERING

Applications are invited for the CHAIR OF CIVIL ENGINEERING.

Salary £S.2760 p.a. Cost-of-living allowance approximately £S130 p.a.; outfit allowance £S50; family allowances: wife, £S60 p.a., first child £S90 p.a., second and third child £S30 p.a. each. (£S1 = £1 0s. 6d. sterling.) Passages for appointee and family on appointment, termination and annual leave. Superannuation scheme. Initial appointment 5 years.

Detailed applications (8 copies), naming 3 referees, by 22 April, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29, Woburn Square, London, W.C.1, from whom further particulars may be obtained. E6505

Classified Advts. continued on page 134

PUBLIC APPOINTMENTS

CAMBRIDGE UNIVERSITY

ENGINEERING DEPARTMENT

HIGHER TECHNICAL ASSISTANT

HIGHER TECHNICAL ASSISTANT required in the drawing-office of the Cambridge University Engineering Department for drawing instruction with some administrative responsibility. Industrial experience essential. Some technial qualifications an advantage. Minimum age 28. Salary in the range £684 by £36 to £869, plus family allowances. Five weeks' holiday with pay ; 40-hour week. Contributory superannuation scheme.—Applications, giving full details of experience and qualifications, should be sent before April 14 to The Secretary, C.U. Engineering Laboratory, Cambridge. E6510

ADEN

PUBLIC WORKS DEPARTMENT

MECHANICAL AND ELECTRICAL ENGINEER

To supervise the Department's workshops and garage dealing with operating, maintenance and overhaul of civil engineering mechanical plant and equipment, including refrigeration.

Contract appointment for 18–24 months in the salary range £1032 to £1929 per annum, with a gratuity of from £25 to £37 10s. per quarter on satisfactory completion of contract. Entry point according to experience. Furnished quarters with refrigerator at low rental. Free medical attention and free passages for the officer, his wife and up to four children under 18. Allowance for education of children outside Aden.

Candidates should be A.M.I.Mech.E., and have had not less than seven years' training and practical experience. An electrical engineering qualification and experience with refrigerating equipment will be an advantage.

Write, Director of Recruitment, Colonial Office, S.W.1, stating age, qualifications and experience, Quote BCD 112/2/018. E6465

NATIONAL COAL BOARD

OPENCAST EXECUTIVE

APPOINTMENTS

National Coal Board, Opencast Executive, invites applications for the following posts :

(1) REGIONAL RESTORATION OFFICER with headquarters in Newcastle. The selected candidate will be responsible for the restoration of land after opencast operations have ceased. Some civil engineering work is involved but the work is mainly concerned with matters connected with drainage and the regrading of land surfaces, fencing, &c. A qualification in Civil Engineering, Estate Management or R.I.C.S. is desirable.

(2) SENIOR CIVIL ENGINEER, with headquarters in Sheffield. Administrative ability coupled with sound, practical experience in the conduct of large civil engineering works in the field is essential. A recognised technical qualification in Civil Engineering is also desirable.

Both posts are superannuable and carry a salary range of £1250–£1850 per annum, the starting salary depending on qualifications, &c.

Applications, giving full details of age, posts held, qualifications, &c., should be made in writing to the Staff Manager, N.C.B. Opencast Executive, 85/87, Jermyn Street, London, S.W.1, within 10 days. E6441

SOUTH WEST SUBURBAN WATER COMPANY

ASSISTANT ENGINEER

Appli tions are invited for the above vacancy in the Chief Engineer's Department.

Candidates should have either an Engineering Degree or have passed Sections I and II of the Institution of Civil Engineer's examination. They should preferably have spent about two years in the water or civil engineering industries.

Duties will be assist in the day-to-day running of the undertaking and with the design and construction of a 3 m.g. reinforced concrete service reservoir. Other new works are contemplated. The company serves an area of approximately 100 square miles, with a population of 200,000.

The salary offered is £800 p.a., or slightly above, according to age and experience. The appointment, which is subject to medical examination, is permanent and pensionable.

Applications, stating age, qualifications and experience, should be sent to the Chief Engineer, South West Suburban Water Company, The Causeway, Staines, Middlesex, as soon as possible.

J. R. BROCK GRIGGS, B.Sc., A.M.I.C.E., M.I.W.E., Chief Engineer.

E6092

KING'S COLLEGE HOSPITAL, DENMARK HILL, LONDON, S.E.5

ENGINEERING DRAUGHTSMAN

Applications are invited for the post of ENGINEERING DRAUGHTSMAN in the Chief Engineer's Department. The salary, dependent on age and qualifications, is in the range £425 by £25 (6) by £30 (2) to £635, plus London Weighting.

Applicants must have experience in drawing-office procedure and practice. The Ordinary National Certificate in Mechanical Engineering or the equivalent would be an advantage.

Applications, stating age, education and experience, together with the names of two referees, should be sent to the Chief Engineer not later than March 28th, 1958. E6489

PUBLIC APPOINTMENTS

GOVERNMENT OF QATAR (PERSIAN GULF)

POWER HOUSE MAINTENANCE ENGINEER

The Government of Qatar in the Persian Gulf has a vacancy for a POWER HOUSE MAINTENANCE ENGINEER in the State Electricity Department.

There are two Power Stations : (No. 1) comprising 7 diesel-alternator sets of 200–540kW. ; (No. 2) 3 diesel-alternator sets of 2600kW, is scheduled for initial operation in May, 1958, and will have an ultimate capacity of 12½ Megawatts.

Applicants, between 40–45 years of age, must have served a Mechanical Engineering apprenticeship and have studied up to the Higher National Certificate and have had considerable experience of the erection, operation and maintenance of diesel engine alternator sets up to 4500 b.h.p., and all ancillary equipments with experience in a modern diesel Power Station and its associated problems.

Appointee may be required to deputise for Power Station Superintendent during his absence on leave or illness.

Salary starting at Rs.2000 per Arabic month (equivalent to approximately £1950 per year), with annual increments of Rs.100 per month up to a maximum salary of Rs.2300 per month.

Contract offered is for five years, subject to six months' probationary period. Gratuity payable on completion of contract. Leave : 6 days for each month on duty, taken annually. Free passages, furnished accommodation, fuel, light, water and medical treatment. No income tax.

Applications, endorsed "Power House Maintenance Engineer, Qatar," accompanied by full personal particulars, including age, education, qualifications, experience, religion and past employment, should be made in writing within 14 days of the date of this advertisement, to :

PREECE, CARDEW & RIDER, 8–12, Queen Anne's Gate, Westminster, S.W.1.

E6486

ATOMIC ENERGY RESEARCH ESTABLISHMENT

HARWELL

REACTOR DESIGN

DESIGN ENGINEERS

Atomic Energy Research Establishment, Harwell, has vacancies for experienced DESIGN ENGINEERS to work on experimental nuclear reactors.

Apprenticeship or equivalent training and H.N.C. essential ; experience of nuclear engineering desirable.

Salary : £880–£1270.

There is also a vacancy for a qualified DRAUGHTSMAN, with O.N.C. or equivalent.

Salary : £555 (at 21)–£865.

Send POST CARD to the Recruitment Officer (1078Y/25), A.E.R.E., DIDCOT, Berks, for application form and details. E6452

GOVERNMENT OF BAHRAIN

BAHRAIN STATE ELECTRICITY DEPARTMENT

SHIFT CHARGE ENGINEERS

Five SHIFT CHARGE ENGINEERS required for a new power station comprising four 1000kW dual fuel engine-driven alternators and three 6100kW Brown Boveri gas turbo-alternators, the latter plant now in course of erection with the first unit to be commissioned for Summer, 1958.

Preference will be given to candidates between 30/45 years of age, with qualifications equivalent to H.N.C., B.O.T. (Steam and Diesel) or C.E.R.A., who have had operating experience on similar generating plant for at least 5 years.

Consolidated salary equivalent to £1550 per annum. There is also a pension fund.

Free furnished bachelor quarters and medical attention provided. Married accommodation provided after satisfactory completion of six months' probationary period. Contract in the first place for a period of two years, subject to six months' probation. Leave is granted at the rate of ten weeks per annum and free passages by air to and from London are provided for the successful candidate and his wife every two years.

Applications in the first instance, giving full details of qualifications, training and experience, to be addressed to the Personnel Officer, EWBANK AND PARTNERS LIMITED, 10/11, Grosvenor Place, London, S.W.1. E6435

NATIONAL COAL BOARD

LONDON

DRAUGHTSMEN

DRAUGHTSMEN required for 3 senior posts in the N.C.B.'s Production Department in London. Sound technical education and practical training are required, with experience in the layout of turbine, boiler and other plant associated with power stations, and ability to work on own initiative from engineer's instructions. Technical qualifications to H.N.C. standard are desirable. Occasional visits to sites in the coalfields and to manufacturers' works will be necessary. Appointments (superannuable) according to qualifications and experience, within inclusive range £843–£1123. Excellent career prospects ; 5-day week, staff restaurant, &c.—Write, stating age, education, qualifications and experience, to National Coal Board, Staff Department (X1090), Hobart House, London, S.W.1, before 28th March, 1958. E6512

PUBLIC APPOINTMENTS

GOVERNMENT OF BAHRAIN

BAHRAIN STATE ELECTRICITY DEPARTMENT

GENERATION ENGINEER

GENERATION ENGINEER required, to take charge of diesel engine, dual fuel engine and gas turbine generating plant with associated auxiliary equipment in two power stations.

Station "A" comprises an installed capacity of 4500kW. diesel engine-driven alternators and Station "B," 4000kW. dual fuel engine-driven alternators and three 6100kW. Brown Boveri gas turbo-alternators, the latter plant in course of erection, with the first unit to be commissioned for Summer, 1958.

Preference will be given to candidates between 35/45 years of age, with qualifications equivalent to Associate Membership of the Institutions of Electrical or Mechanical Engineers and having had operating experience on similar generating plant for at least 5 years.

Consolidated commencing salary up to £2250 per annum, according to qualifications and experience. There is also a pension fund.

Free furnished bachelor quarters and medical attention provided. Married accommodation provided after satisfactory completion of six months' probationary period. Contract in the first place for a period of two years, subject to six months' probation. Leave is granted at the rate of ten weeks per annum and free passages by air to and from London are provided for the successful candidate and his wife every two years.

Applications in the first instance, giving full details of qualifications, training and experience, to be addressed to the Personnel Officer, EWBANK AND PARTNERS LIMITED, 10/11, Grosvenor Place, London, S.W.1. E6436

COMMONWEALTH RELATIONS OFFICE

AUTOMOBILE ENGINEER

Applications are wanted by the Commonwealth Relations Office for an appointment as AUTOMOBILE ENGINEER in India, under the Technical Co-operation Scheme of the Colombo Plan. Will be required to examine the maintenance establishments of State Transport undertakings and advise on improving the methods of reclaiming worn-out parts of vehicles and the maintenance facilities in general. Must hold a University Degree in Engineering or A.M.I.Mech.E., and have full knowledge of the latest methods for the reclamation of worn-out motor vehicle parts. Duration one year in the first instance. Contract with the U.K. Government. Salary, £2000 per annum (subject to U.K. income tax), plus tax-free oversea allowance of £1190 per annum (married) or £640 per annum (single), plus other allowances and free furnished accommodation.

For further information and application forms, write Ministry of Labour and National Service (E.9), 26–28, King Street, S.W.1, quoting A.12/IND/179/TCS. E6518

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

ALDERMASTON, BERKS

APPRENTICE SCHOOL MANAGER

APPRENTICE SCHOOL MANAGER required by the Atomic Weapons Research Establishment, Aldermaston, Berks, to control an apprentice training school covering the practical training requirements of approximately 200 apprentices in the Graduate, Student, Technician and Craft categories under training in mechanical, electrical and electronic skills. He will be responsible for :—

(a) Preparation of schedules of training appropriate to the varying capacities of apprentices to absorb knowledge.

(b) Liaison with engineers in charge of site workshops on all aspects of practical training provided, and

(c) Liaison with appropriate training staff to ensure a proper balance between practical and theoretical training.

A recognised engineering apprenticeship and Corporate Membership of the Institution of Mechanical or Electrical Engineers, or exempting qualifications, essential. Experience in electronics and of apprentice training schemes is required. Ability and willingness to give guidance towards a broad education, to organise sport and recreational activities and to take personal interest in each apprentice, combined with a pleasantly firm personality are essential.

Salary : £1300–£1740 per annum.

Contributory superannuation scheme. A house or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at above address. Please quote Ref. 1735/25. E6279

THE LONDON HOSPITAL, WHITECHAPEL, E.1

ENGINEERING DRAUGHTSMAN

ENGINEERING DRAUGHTSMAN, experienced in all aspects of services layout. Work in connection with the modernisation and replacement of services equipment in a large hospital. Duties entail thorough knowledge of steam, hot water, air distribution and associated equipment. Salary will depend on the experience and qualifications of the applicant.

Applications, giving details of training, experience and qualifications, should be sent to the House Governor, The London Hospital Whitechapel, E.1. E6509

PUBLIC APPOINTMENTS

WEST CUMBERLAND HOS... MANAGEMENT COMMITT...

APPOINTMENT OF SUPERINTEN... ENGINEER

Applications are invited for the post of ... INTENDENT ENGINEER and ENGI... CLERK OF WORKS to the West C... Hospital Management Committee.

Applicants should have a thorough ... mechanical engineering training and ... sound knowledge of the principles and ... the efficient operation of steam boiler ... have had a wide experience in a supervis... of mechanical and electrical engineer... generally. They should possess at least ... following qualifications or recognised equi...

First Class Certificate of Competency ... Engineering or equivalent Naval Certific...

City and Guilds Full Technological C... Plant Engineering (First Class).

Higher National Certificate or D... Mechanical Engineering.

The successful applicant will be respo... Hospital Management Committee for the ... operation, maintenance and co-ordinatio... engineering services within the Group. ... the duties of Engineering Clerk of Works ... West Cumberland Hospital, now under ... are included in the appointment and ... appointed will require to supervise the ... all the engineering services associated ... capital work.

The appointment is superannuable and ... will be £855 by £25 (2) by £30 (1) by ... £1005 per annum. If not already in the ... Service, the successful applicant will ... medical examination. A newly-built ... house on the site can be made available ...

Applications, stating age, qualifications ... and present and previous appointments ... with the names and addresses of three ... technical), should be forwarded to the ... Secretary, West Cumberland Hospital ... Committee, Workington Infirmary, ... not later than fourteen days after the ... of this advertisement.

FYLDE WATER BOARD

APPOINTMENT OF GRADU... ASSISTANT

The Board invite applications for the ... appointment, duties to commence in ... 1958.

Salary in accordance with the Nation... Salaries, commencing on A.P.T. Grade ... annum.

Candidates should have successfully ... University Degree Course in Engineer... doing so this summer.

The Board has an extensive program... in hand, giving ample opportunity for ... applicant to gain practical training and ...

The appointment will be subject to the ... of the Local Government Superannuation ... and Regulations thereunder, and the succe... date will be required to pass a medical ...

Forms of application can be obtained ... undersigned, to whom applications, and ... copies of two recent testimonials or ... "Graduate Assistant," must be delivered ... than 9th April, 1958.

FRANK ... B.Sc. Tech., ... Engineer ...

Sefton Street, Blackpool.

COUNTY BOROUGH ... DARLINGTON

SENIOR ENGINEER

Applications are invited from persons ... minimum qualification of the Ordinary ... Certificate in Mechanical Engineering, ... and Heat Engines, or the Second Class ... of Competency in Marine Engineering ... Naval Certificate for the post of SENIOR ... NEER at East Haven, Yarm Road, ... which is a large residential home ... attached.

Salary within Grade £615 to £76... Conditions include three weeks' annual ... usual Bank Holidays sick pay and superannuation ... schemes.

Applications to be sent, giving age, ... previous appointments, &c., to the ... later than Saturday, 22nd March, 195...

H. H... Town ...

11, Houndgate, Darlington.

AIR MINISTRY WORKS ... BRANCH

LONDON

DESIGNER DRAUGHTS...

Air Ministry Works Design Branch, ... London DESIGNER DRAUGHTSMEN ... Petroleum Storage and Pumping ... experienced in one or more of the ... storage tank layout and design ... and plant layout ; (c) development ... schemes ; (d) hydraulic calculations ... training to O.N.C. standard required.

Salaries up to £1015 per annum, ... dependent on age, qualifications ... term possibilities with pensionable ... prospects. 5-day week, 3 weeks' holiday. ... Normally natural born British subjects.

Write, stating age, qualifications, ... details, including type of work done to ... ment Exchange, quoting Order No. ...

PUBLIC APPOINTMENTS

OL REGIONAL HOSPITAL BOARD

INEERING ASSISTANTS

are invited from suitably qualified the following permanent pensionable on the staff of the Regional Engineer:—

RING ASSISTANT (Mechanical)—

must be conversant with the design of ntilation systems in hospitals or build- reparation of estimates, drawings and

RING ASSISTANT (Electrical)—

ould be experienced in the preparation , drawings and estimates for distribu- lectrical installations in hospitals and be able to take details of existing d have a good knowledge of modern ction.

alification for the above appointments National Certificate in Mechanical or neering.

salary for each post within the scale annum, dependent on age and pre- ractical experience.

stating age, qualifications, experience, vious appointments, with names and ree referees (two technical), stating d for, to me at 19, James Street, Liver- er than 27th March, 1958.

VINCENT COLLINGE,
Secretary to the Board.

E IMPROVEMENT COMMISSION

ENGINEERS

provement Commissioners invite n qualified persons for the posi-

NT CHIEF ENGINEER, and (b) STANT ENGINEER, under their Mr. R. B. Porter, M.I.C.E.

r each position must be Chartered with extensive experience in the ion and maintenance of dock and l installations.

ng salary, which will have regard to s and experience of the successful

on of Assistant Chief Engineer, not per annum.

on of Senior Assistant Engineer, not per annum.

st not be less than 32 years of age 45 years of age on the 1st January,

ppointed will be subject to the pro- Commissioners' superannuation required to reside in the district and f exclusively to the service of the

on a prescribed form, copies of which d from the undersigned, will be the 10th April, 1958, and should be Secretary endorsed to indicate the h application is made.

ll be a disqualification.

R. N. EGGLETON,
Secretary.

oon Tyne, 1,
h, 1958. E6477

NAL COAL BOARD

BRETBY, NR. BURTON-ON-TRENT

ENGINEER

with wide electrical experience, .C.B.'s Headquarters Production located at Stanhope Bretby, near . Applicants should have consider- in the preparation of maintenance g machinery and plant connected Industry and be able to prepare orts and draft technical instructions. nvolve a considerable amount of least H.N.C. (or equivalent) is bly with membership of a recognised ion. Appointment (superannuable), alifications and experience, within 50.

tional Coal Board, Staff Dept., rt House, London, S.W.1, for appli- h should be returned by 24th March, E6440

DUCATIONAL

LEGE OF AERONAUTICS

SCHOLARSHIP

are invited for the PERRING IN AERONAUTICS, valued £500 ble at the College of Aeronautics, andidate will be admitted to the t the College.

uld preferably be Honours Gradu- er Undergraduates in Engineering, Physics; applications from non- comparable qualifications will also Candidates must be British subjects United Kingdom.

cation and statement of conditions d on written application to The ollege of Aeronautics, Cranfield, te for the receipt of applications is E6127 E

EDUCATIONAL

ROYAL CORPS OF NAVAL CONSTRUCTORS

ENTRY FROM PRIVATE SHIPYARDS

A Competitive EXAMINATION for ENTRY into the ROYAL CORPS OF NAVAL CONSTRUCTORS will be held in June, 1958. Accepted candidates will be entered as Probationers in the Royal Corps and will receive a Course of Training mainly at the Royal Naval College, Greenwich. Candidates must not be more than 26 years of age on 1st October, 1958, and must have been engaged in practical shipbuilding for at least eighteen months before entry.

2. Work covers all aspects of design, construction and repair of warships and gives opportunities for service in H.M. Dockyards abroad and in the United Kingdom.

3. Full particulars, including details of substantially improved salaries now payable, may be obtained upon application to the Secretary of the Admiralty (C.E. Branch II), Bath. Intending candidates must send to that address, before the 1st April, full particulars of their education and technical training, and of their practical experience.

PRIVATE STUDENTS OF NAVAL ARCHITECTURE

In conjunction with the above, a qualifying examination will be held for Private Students who desire to take the same Course as that prescribed for Officers of the Royal Corps of Naval Constructors under training. Candidates' applications should reach the Secretary of the Admiralty (C.E. Branch II), Bath, before 1st May. A fee of £50 per session is at present payable by private students taking this Course, but the amount payable is under review.

E6392

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

POST-GRADUATE COURSE IN PRODUCTION ENGINEERING

Applications are invited from Graduates for a ONE-YEAR FULL-TIME COURSE IN PRODUCTION ENGINEERING, leading to the Diploma of the Imperial College (D.I.C.), which will begin in October, 1958.

Further particulars can be obtained from the Registrar, Imperial College, London, S.W.7. E6428 E

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E721 E

FREE! Brochure giving details of Courses in Mechanical and Production Engineering, Draughtsmanship, &c., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other professional examinations. —E.M.I. Institutes, Dept. E.30, London, W.4. (Associated with H.M.V.) E972 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED

A PROMINENT BRITISH MERCHANT HOUSE in Malaya offers an attractive and progressive appointment to EXECUTIVE, aged 35–42, with successful commercial engineering record, to take charge of all their engineering activities involving the sale, installation and servicing of a wide range of engineering plant and equipment and the representation of many well-known U.K. manufacturers. Some overseas experience probably indispensable. This senior post involves control of technical staff and direct responsibility to the Board for the success of a major department. Total remuneration would be not less than £4000 per annum.—Apply, with full details, to BOX No. W1579, Haddon's, Salisbury Square, E.C.4. E6470 A

ALLENS OF BEDFORD
have a vacancy for
AN ASSISTANT TO THE WORKS ENGINEER

The post carries responsibility for the Architectural and Civil Engineering design of new buildings and for modifications to, and maintenance of, existing buildings.

Essential qualifications are a sound technical education and at least 3 years' experience in the design of industrial buildings. Experience in estimating, surveying and site supervision will be useful.

Generous pension scheme. Assistance towards moving expenses.

Apply, stating age and full details of experience to the Personnel Manager, W. H. Allen Sons & Co., Ltd., Queens Engineering Works, Bedford. E6360 A

APPLICATIONS ARE INVITED for the following appointments at the CLAYDON, SUFFOLK, Works of

THE BRITISH STEEL PILING CO., LTD.

SENIOR DESIGNER DRAUGHTSMAN (Minimum qualifications H.N.C. or equivalent.) Age group 28–35 years. Candidates should be capable of accepting responsibility for complete projects.

MECHANICAL DRAUGHTSMAN (Young) (Minimum qualifications O.N.C.) Required for Research and Development Team.

THESE APPOINTMENTS ARE PERMANENT AND PROGRESSIVE IN AN EXPANDING ORGANISATION, and the successful candidates will be engaged on interesting work in connection with special crane type structures, hoisting machinery (steam, diesel, electric) and contractors' plant.

Contributory pension scheme in operation. Good canteen facilities. Salary in accordance with qualifications and experience. The works are situated 15 minutes bus ride from the centre of Ipswich.—Applications to the Personnel Officer at the above address. E6404 A

SITUATIONS VACANT

APPLICATIONS INVITED FOR

(a) DESIGNER AND DETAIL DRAUGHTSMEN, for general mechanical engineering, pipework, platework, pressure vessels, heat exchangers, &c.
(b) ELECTRICAL ENGINEERING DRAUGHTSMEN, for complete electrical installation and design work, including motor application, control scheme engineering.
(c) REINFORCED CONCRETE DESIGNER, experienced in the design of foundations and structures for heavy industrial plants.
(d) INSTRUMENT DRAUGHTSMEN, for design, selection, installation, commissioning of modern plants for a rapidly expanding instrument department of Chemical Plant Division.

High salaries, pension scheme. Grant towards removal expenses and living allowance until removal is effected.—Apply, The Power-Gas Corporation, Ltd., Stockton-on-Tees. E6147 A

APPLICATIONS ARE INVITED FROM ENGINEERS for responsible posts on research and development of Automation Techniques and Production Processes for the engineering industry. Excellent opportunities for those with ability and initiative. Previous experience not essential. Candidates should have an Engineering Degree, Higher National Certificate, or equivalent qualification. Send full details including age, qualifications, experience and present salary, in confidence.—BOX No. E6447, "The Engineer." A

ASSISTANT DIVISIONAL CIVIL ENGINEER — A man with extensive experience in the design and construction of large-scale civil engineering work is required for the post of Assistant Divisional Civil Engineer in the West Midlands Division of the National Coal Board. The duties will be concerned with the large and varied programme of civil engineering works, including major colliery reconstruction schemes, in which the Division is engaged. Applicants should preferably be Corporate Members of the Institution of Civil Engineers, but consideration would be given to Corporate Members of the Institution of Structural Engineers who have adequate civil engineering experience. Salary will be within the range £1250–£1850.—Applications, quoting EN, on forms obtainable from Divisional Chief Staff Officer, West Midlands Divisional Coal Board, Himley Hall, Dudley, Worcs, by March 27, 1958. E6461 A

ASSISTANT TO TECHNICAL ENGINEER, age 21/25, must have some drawing-office experience; O.N.C. in Mechanical Engineering desirable; knowledge of hydraulics and/or automotive engineering an advantage.—Apply in writing, with full particulars and salary expected, to Secretary, E. P. Barrus, Ltd., 12–16, Brunel Road, London, W.3. E6383 A

W. S. ATKINS & PARTNERS
ANNOUNCE
that they have a vacancy for a SENIOR ENGINEER familiar with the design of steam raising plant, auxiliaries and associated services. A working knowledge of electrical power generation would be an added advantage.—Applications in writing to Personnel Manager, 158, Victoria Street, S.W.1. E6454 A

BERMUDA.—REFRIGERATION ENGINEER, preferably single and between the ages of 27 and 40, required for installation and service of commercial and domestic refrigeration and air conditioning equipment, fully qualified, with sound technical background and extensive practical experience; qualifications and character references required; salary £1248; no income tax, passage paid subject to contract; full details, training and experience.—BOX No. E6514, "The Engineer." A

BRITISH CELLOPHANE, LIMITED, BRIDGWATER, SOMERSET INVITES APPLICATIONS FOR ENGINEERING POSTS IN ITS RESEARCH AND DEVELOPMENT DIVISION, AS FOLLOWS:

MECHANICAL ENGINEERS

Applicants should be Graduates or A.M.I. Mech.E. or both, aged 25/50, and are required for :—

(a) Development of plant used for the manufacture of Polythene film. Practical experience must have included an engineering apprenticeship, post graduate experience in maintenance and construction of a light engineering character desirable, previous experience in the extrusion of plastic films an advantage. Ref. No. R66. Er.
(b) Development work on applying aqueous dispersons of polymers as coatings to cellulose films. Engineering apprenticeship essential, post graduate practical experience in construction of a light engineering character desirable, experience in methods of applying thin coatings would be an advantage. Ref. No. R67.Er.

Applications, giving details of age, past experience and qualifications, should be addressed to the Personnel Officer, quoting Ref. Nos. as shown. E6405 A

BRUCE PEEBLES AND CO., LTD., require Two ENGINEERS of H.N.C. standard for their Transformer Sales and Contracts Department. 5-day week. Staff pension and bonus schemes.—Apply, giving details of training and experience, to Manager, Transformer Dept., East Pilton, Edinburgh. E6362 A

SITUATIONS VACANT

ASSISTANT WORKS MANAGER required by well-established Paper Converting Company in North West London area. Candidates should be between the ages of 30 and 40 and have a sound mechanical engineering background with at least some knowledge of electricity. They should have also initiative and good administrative ability. The initial salary is up to £1500 per annum, according to qualifications and the prospects are excellent. Apply at first in writing, giving details of previous experience. —BOX No. E10, "The Engineer." A

CHIEF DESIGN ENGINEER

A Design Engineer will shortly be required to take charge of a Development Section to be established in the Manchester area for a group of companies. The post calls for a man of ability, imagination and experience in the design of new and improved lifting and handling equipment, including overhead travelling cranes, conveyors and hoist blocks. Only applications giving full details of experience will be considered, and will be treated in strict confidence.—BOX No. E6444, "The Engineer." A

CHIEF ENGINEER

A large and expanding food company of international repute have a vacancy for a Chief Engineer to take executive responsibility for a modern food processing plant, employing 1400, located on Merseyside.

The post carries responsibility for all aspects of engineering, including maintenance and installation of plant, equipment and buildings. All services, including large-scale refrigeration and air conditioning. Efficient operation of processing, packaging and bottling equipment.

Applicants should possess University Degree in Engineering, or its equivalent, and have had considerable experience in a similar capacity. The post, which is superannuated, offers a good salary and considerable scope.

Write, giving full details of age, qualifications and previous experience, to Personnel Manager, —BOX No. E1693, "The Engineer." A

CHIEF ENGINEER required for large manufacturing company in food trade in Glasgow. Successful applicant required to maintain all plant in high state of operating efficiency. Previous experience of baking ovens desirable. Further responsibilities include maintenance of all usual services and buildings, &c. Age 35/45. Commencing salary £1400/£1700 p.a. Write, stating age, qualifications, and brief summary of career, including salaries earned.—BOX No. E1705, "The Engineer." A

CIVIL ENGINEER for research in the Soil Mechanics Division of the Road Research Laboratory, D.S.I.R., at Harmondsworth, Middlesex, on soil stabilisation—an actively developing field in relation to road-base construction. The appointment is to the staff of the Chalk Lime and Allied Industries Research Association working at the Laboratory. Applicants should have Honours Degree or equivalent qualification. Salary and grading appropriate to qualification and experience. The appointment is permanent, with superannuation under F.S.S.U.—Apply to Director of Research, C.L.A.I.R.A. Laboratories, Church Street, Welwyn, Herts. E6488 A

CIVIL ENGINEERS AND DESIGNER-DRAUGHTSMEN required by consulting engineers in Victoria, London, for varied, interesting and responsible work. Applicants should be qualified and experienced in the design af reinforced concrete structures with special experience in one or more of the following :—Marine, bridge, general, including foundations and prestressing. Should be able to work without supervision and undertake unorthodox design. Attractive salary and prospects. Office hours 9.30–5.30 and one Saturday morning in six.—Application forms may be obtained from Personnel Dept., Sir Bruce White, Wolfe Barry and Partners, 1, Lygon Place, Grosvenor Gardens, London, S.W.1 (Tel.: Sloane 3433). E6443 A

CIVIL/STRUCTURAL ENGINEERS, with extensive experience in design of power station and heavy industrial structures, required by Consultants. Starting salaries from £1200 to £1600 p.a.—BOX No. E6410, "The Engineer." A

CONTROL ENGINEER.—A Control Engineer is required for work in connection with Gas Turbines and Nuclear Energy developments. Applicants should hold a Degree in Mechanical Engineering or equivalent qualifications, and should have experience in the design and development of control systems. The salary, responsibilities and prospects will depend on the experience and ability of the applicant, who should write, giving full particulars, to the Personnel Manager, C. A. Parsons and Co., Ltd., Heaton Works, Newcastle upon Tyne, 6. E6498 A

DEVELOPMENT ENGINEERS

Exceptional opportunities for three graduate, apprentice-trained, Mechanical Designers in 25/35 age group occur in our organisation. Successful candidates will be given experience of our product before taking responsible positions in our expanding Development and Design departments.

Requirements: Degree or equivalent qualifications and some development and design experience, especially in machine dynamics, strength of materials elasticity, &c.

Staff conditions, salary, pension scheme, &c., are up to the standard expected by those genuinely qualified for these posts.

Candidates should write initially to the Secretary, The British Northrop Loom Company, Limited, Blackburn, Lancashire. E1700 A

Classified Advts. continued on page 136

SITUATIONS VACANT

DESIGNER/DRAUGHTSMAN, with experience of small mechanisms. Preferably over 25. Unusual opportunity with progressive light engineering company. 5-day week ; good salary. Holiday arrangements respected. Interviews to suit applicants.—Apply, Mr. Carr, Factory 5, Rotaprint, Ltd., Honeypot Lane, London, N.W.9. E1711 A

DEVELOPMENT ENGINEERS required by large light alloy manufacturing organisation in West London area. Applicants must possess knowledge of light alloy fabrication, have drawing-office and design experience, and at least five years' workshop training. Salary commensurate with qualifications and experience, contributory pension scheme in operation. Write, giving full details.—BOX No. E6481, " The Engineer." A

DRAUGHTSMAN required, preferably with some experience of chemical plant and the operation of shell boilers. Applicants should be of H.N.C. standard. The work is interesting and covers the installation of new and alteration to existing plant, and involves a certain amount of site work. A pension scheme is in operation and a canteen available. —Apply, giving age, qualifications and experience, to Chief Engineer, Lancashire Tar Distillers, Ltd., Liverpool Road, Cadishead, Nr. Manchester. E6480 A

DRAUGHTSMAN, £950 p.a., required for pipework design/layout/detail work in Bristol. Boiler pipework experience essential. Pension scheme.—BOX 2899, Blackford's Advertising, Bristol. E6397 A

DRAUGHTSMAN/ENGINEER, for senior position, preferably experienced chemical and mechanical engineering, prepared to travel occasionally on plant operation and progressing, also organisation draughting and estimating departments, small London office. Excellent opportunity with suitable remuneration. Particulars, including indication salary required,—BOX No. E1698, " The Engineer." A

DUST EXHAUST ENGINEER required by Spencer and Halstead, Ltd., 8, West Street, Epsom, to have freedom to show initiative and ability to develop sales, design and installation of large and small contracts in Southern England and South Wales.—Write full details, marked personal, to Technical Manager. E1713 A

ELECTRICAL ENGINEERS.—A large Engineering Group who have their H.Q. in Birmingham, have a few vacancies for Electrical Engineers in a Department that provides a consulting service for a group of factories. Applicants should have had good experience on industrial electrical equipment and a Degree or its equivalent in Electrical Engineering is a desirable qualification. The company operates a superannuation scheme. Brief particulars of education, training and experience, should be included in application, addressed to Personnel Manager.—BOX No. E6449, " The Engineer." A

ELECTRICAL DESIGNER DRAUGHTSMAN

required by

W. H. ALLEN SONS & CO., LTD., BEDFORD

for the development and design of A.C. and D.C. motor control gear.

This is a permanent appointment on interesting work, with good prospects.

Generous Pension Scheme. Assistance towards removal expenses.

Apply in writing, giving full details of experience, to the Personnel Manager E6450 A

ENGINEER

required in

DEVELOPMENT LABORATORIES

for stress analysis and vibration problems.

Applicants should have a good Degree in Mechanical Engineering, together with ability to make a mathematical approach to problems. Some experience in industry and in the use of electronic equipment is desirable.

The position carries an attractive starting salary and provides excellent opportunities for further advancement. Staff pension fund.

Apply in writing, stating age, qualifications and experience, to the Personnel Manager, JOSEPH LUCAS (ELECTRICAL), LIMITED, Great King Street, Birmingham, 19, quoting reference PM/D/192. E996 A

ENGINEER, aged 25/35, required by West London food manufacturers for a new appointment in the engineering department, to supervise costs, estimates and method study. Applicant should have sound engineering background, with previous experience in methods and/or estimating. Write, stating age and experience.—BOX No. E6472, " The Engineer." A

ENGINEER.—Old-established firm of Consulting Engineers and Marine Surveyors in Singapore, require further Assistant, age about 30. Minimum qualification A.M.I.Mech.E., or 1st Class M.O.T. (Combined) Certificate (with drawing-office experience an advantage). Variety of firm's activities includes Marine and Land Projects, Classification Surveys, Superintendents' duties, Design and Supervision of new construction. Write for further details, giving brief summary of experience. Interview can be arranged in U.K.—BOX Z.O.685, Deacons Advertising, 36, Leadenhall Street, London, E.C.3. E6492 A

ESTIMATOR required by PETER LIND & CO., LTD., Romney House, Tufton Street, Westminster, S.W.1. Experienced in estimating for civil engineering and reinforced concrete work.—Apply in writing, giving age, experience and salary required. E6453 A

EXPERIENCED CRANE DESIGNERS required in Glasgow. Minimum qualification H.N.C., preferably aged 30 or over. Commencing salary not less than £900 per annum. Pension scheme. Full details. —BOX No. E6417, " The Engineer." A

ENGINEERS FOR MIDDLE EAST

(a) Qualified MECHANICAL ENGINEERS having full experience pump stations and tank farms for product pipeline construction.

(b) Qualified SUPERINTENDENTS for construction sea-line and mooring facilities.

Submit curriculum vitæ (a) and (b) to BOX No. 1562, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E6484 A

FORENSIC ENGINEERS invite application from CIVIL ENGINEERING GRADUATES with good background and site experience, for responsible and individualistic post. Age about 30 years.—BOX No. E6445, " The Engineer." A

W. T. GLOVER & CO., LTD.,
TRAFFORD PARK, MANCHESTER, 17,
have the following vacancies :—

MECHANICAL ENGINEERING DRAUGHTSMEN, for design and development of cable making machinery.

Applicants should preferably have had workshop experience.

DRAUGHTSMAN FOR ACCESSORIES DRAWING-OFFICE.

Minimum qualification O.N.C.

The work will involve detailing and constructional drawings for cable and accessories up to and including 275kV.

5-day week. Staff Pension Scheme.

Applications, stating age, experience and salary required, should be addressed to the Secretary. E1708 A

JACKSON BROS. (OF KNOTTINGLEY) LTD.
require a young ENGINEER for maintenance and development work in modern glass-container works. The post is permanent and pensionable and offers scope for further training and advancement. Previous experience in glass-works not necessary.

Successful applicants must have served an engineering apprenticeship, must be either a Graduate Member of the I.Mech.E., or studying for this qualification, and have had some experience in general works maintainence.

Preference will be given to applicants with a knowledge of modern machine-shop practice and/or automatic machinery maintenance.

Applications to Personnel Officer, Jackson Bros. (of Knottingley), Ltd., P.O. Box No. 2, Knottingley, Yorkshire. E6467 A

KENNEDY AND DONKIN require a number of MECHANICAL and ELECTRICAL ENGINEERS, with First or Second Class Honours Degrees, to assist in their work as consulting engineers for nuclear electricity generating stations. The appointments would be initially in London or in Manchester, but all applicants must be prepared to move to London in about two years' time.—Application forms may be obtained from Kennedy and Donkin, 64, Royal Exchange, Manchester, 2. E6438 A

JOHN LAING AND SON, LIMITED,
invite applications from
ASSISTANT SITE ENGINEERS
with experience of setting-out and general site engineering duties on a variety of important contracts in the British Isles. A Civil Engineering Degree or the equivalent is desirable but not essential.

Those interested should write to :—
Personnel Manager (A.S.E.1),
John Laing and Son Limited,
London N.W.7. E6402 A

LOCKHEED HYDRAULIC BRAKE CO., LTD.,

require a

QUALITY CONTROL METHODS ENGINEER

responsible direct to the Chief Inspector, to undertake investigations into problems of quality and who will advise Industrial Engineers and Divisional Inspectors on the application of modern methods of planning quality control.

It is essential that applicants have served an engineering apprenticeship and have had experience of modern planning methods, including control of quality, and have a sound technical background, preferably to H.N.C. standard or equivalent.

This is an interesting post, covering a wide field of activity.

Applications, in writing, giving full details of age, experience and qualifications, to the Employment Officer, Lockheed Hydraulic Brake Co., Ltd., Tachbrook Road, Leamington Spa, Warwickshire. E6496 A

MACHINE TOOL DRAUGHTSMAN with process planning experience, required to check and advise on production drawings. Age approximately 25–45 years. London area. A good technical education and a minimum of 5 years in a machine tool drawing-office are essential. Please reply, stating age, details of education and experience, including firms worked for, and salary expected, in confidence.—BOX No. E6456, " The Engineer." A

MECHANICAL DRAUGHTSMAN. — Large commercial and industrial organisation has vacancy in London head office for a Senior Mechanical Draughtsman. Applicants must have had extensive experience in layout of machinery and boilers, and possess a good all-round knowledge of general engineering. Some building experience would be an advantage. For the right man the prospects are excellent and there is a non-contributory pension scheme.—Write, giving age and details of experience, to BOX No. E6321, " The Engineer." A

JOSEPH LUCAS (ELECTRICAL), LIMITED,
have vacancies for
ASSISTANT DEVELOPMENT ENGINEERS
to work on the design and development of automobile generators, alternators and starting motors and also of motor-cycle electrical equipment, including equipment to be used for racing purposes. Applicants should be of Higher National standard and should have had previous experience in electrical design. Five-day week, staff pension fund.

Apply in writing, stating age, qualifications and experience, to the PERSONNEL MANAGER, JOSEPH LUCAS (ELECTRICAL), LIMITED, Great King Street, Birmingham, 19, quoting reference PM/D/176. F995 A

MACFARLANE LANG & CO., LTD., Victoria Biscuit Works, Glasgow, invite applications from suitably qualified persons aged 35 to 45, for the post of CHIEF ENGINEER.

The duties of the position include responsibility for maintaining all operating plant in a high state of efficiency, and also the maintenance of all buildings and usual services. Knowledge of Biscuit Manufacturing Plant an advantage.

Salary commensurate with the duties and responsibilities involved.

Written application, stating age, qualifications and details of experience, to H. P. Bradshaw, Stevenson Jordan and Harrison, Ltd., 163, West George Street, Glasgow, C.2. E1715 A

MARINE ENGINEERING CO. on upper reaches of Clyde, require DRAUGHTSMEN for Turbine Details ; also for Steam and Motor Ship Pipe arrangements. Good staff conditions, pension scheme after qualifying period of satisfactory service. —Write, 0736, Wm. Porteous and Co., Glasgow. E6490 A

MECHANICAL ENGINEER

Position available with prominent British company for young, qualified, Mechanical Engineer for heavy chemical plant development. A sound technical background essential and preferably with experience in chemical plant layout and design. The appointment would be based on London. Good pension scheme and other amenities. Please reply, giving details of age, qualifications and experience.—BOX No. E6503, " The Engineer." A

MECHANICAL ENGINEER required by British-controlled civil engineering company in Pakistan. Must be qualified and have extensive experience with contracting firms as Plant Engineer-Manager, with administrative experience, planning and cost accountancy ; age 35–45. Salary £2500 to £2750 per annum, according qualifications and experience.—BOX No. E1707, " The Engineer." A

MECHANICAL ENGINEER
required for design of rotating electrical plant, including large hydro-generators. Experience in this class of work desirable but not essential. Applicants must have practical and drawing-office engineering experience. Minimum technical qualifications : Higher National Certificate in Mechanical Engineering. Compulsory pension and superannuation scheme. Assistance given with housing.—Apply, giving details of experience, &c., and salary required, to Manager, Rotating Plant Department, Bruce Peebles and Co., Ltd., Edinburgh, 5. E6463 A

MECHANICAL ENGINEERS — University Honours Graduates or A.M.I.Mech.E. The work entails the investigation of technical problems and the development of plant improvements in connection with a continuous chemical process. Applicants should be between the ages of 25 and 32 and preferably have some years' industrial experience.—Please write to the Personnel Officer, British Cellophane Limited, Bridgwater, Som., and quote Ref. No. E83Er. E6497 A

MECHANICAL SALES ENGINEER (about 30) required by British Company for CEYLON, where a wide range of engineering products is marketed. Starting remuneration is dependent upon experience and ability ; progression on merit. Generous home and local leaves, outfit allowances, an annual merit bonus, pension scheme and provident fund are included in terms of service. Applicants, preferably G.I.Mech.E., should write full details.—BOX No. E6451, " The Engineer." A

METHODS ENGINEER required for Engineering Methods Department of J. B. Brooks and Co., Ltd., Birmingham. Experience of presswork, flowline production and shop layout essential. This is an excellent opportunity for a suitably qualified man with initiative to join an expanding and progressive company in which up-to-date equipment and techniques are used.—Apply in confidence, giving details of age, education, experience and salary required, to Personnel Manager, Great Charles Street, Birmingham. E1704 A

OPENING FOR TECHNICAL REPORT WRITER. Good prospects. Salary around £1500. A wide knowledge of mechanical engineering, varied experience in design and product development and familiarity with current developments in machinery, materials and components are desirable qualifications. —BOX No. E6473, " The Engineer." A

OPPORTUNITIES exist for SCIENTIFIC STAFF in expanding company, West of England, for men with sound experience in metal practice—sheet metal work, fine tool and light industries. Send full details of experience and salary required, addressed to Managing Director, BOX No. E1710, " The Engineer." A

PRODUCTION ENGINEER—an opening for a man with drive and the ability to make improvements in the manufacture of moulded and rubber and plastic mouldings. Salary £1200 per annum, with eligibility for pension. Head office in the Manchester area.—BOX No. E6365, " The Engineer." A

READS OF LIVERPOOL

ENGINEER, with work study training, at least three years' experience of factory flow production, materials handling and transportation, required by a rapidly expanding company engaged in the manufacture of containers. The appointment offers good prospects to a man possessing drive and initiative and who is capable of accepting responsibility. Apply to :

The Senior Personnel Officer, (NG/Mis),
Reads, Limited,
Orrell Lane,
Liverpool, 9.

OUTSTANDING OPPORTUNITY A

Large Electrical Manufacturer in West of England requires

(a) WORKS MANAGER

and

(b) PRODUCTION ENGINEER

for

FACTORY

being built for the production of

NEW LIGHT ELECTRICAL PRODUCT

Experience in 'flow' mass production methods desirable, but not essential, in electrical production. Extensive recreational and social facilities. Profit-sharing and superannuation schemes.

APPLY:— in first instance, giving full details and experience, to BOX No. E6[illegible], " The Engineer."

(N.B. All applications will be treated in strict confidence.)

ALEXANDER STEPHEN & SONS, LIMITED,
SHIPBUILDERS AND ENGINEERS
have vacancies in their
ENGINEERING DEPARTMENT
for
HONOURS GRADUATES AND H.N.C. MECHANICAL ENGINEERS
for design study and development work on progressive marine machinery installations of all major types.

Age 26–32 preferred, with experience in steam or heavy engineering experience.

Apply, giving particulars to :
The Secretary,
Alexander Stephen & Sons,
Linthouse, GLASGOW, S.

A large toolmaking firm in Birmingham has a vacancy for an experienced high class

PRODUCTION CONTROLLER

aged 35 to 50. High salary offered to a suitable candidate.

For further details contact Technical Advisory Service, Birmingham Productivity Association, 95, New Street, Birmingham. Telephone MIDland 0912.

SITUATIONS VACANT

GINEER REQUIRED, with good background, apprenticeship and H.N.C., n initiative in dealing with customers, ner applications and in submitting ers for compressed air and industrial . Personnel Manager (TCS), Birlec burn Road, Erdington, Birmingham. E6487 A

SALES MANAGER
ledge of building or building materials required in Birmingham, for develop- supervision of sales organisation specialised building material. 40, with good sales experience and a technical qualification appropriate traction industry. first instance, stating age, experience cations, to : rsonnel Manager (CHW.6), rmalite, Ltd., 3139, Page Street, ondon, N.W.7. E6493 A

CIVIL ENGINEERING AGENT
o control large-scale motor road and ancillary works. Candidates perience of planning and con- use of up-to-date road construction To succeed in this post it will be o possess the ability to co-ordinate ster a scattered contract with a completion date. Applications ddressed to :— OR PERSONNEL OFFICER, CHARD COSTAIN, LTD., Westminster Bridge Road, London, S.E.1. E6516 A

R MECHANICAL DESIGN ENGINEER
ndustrial engineering company of repute would be pleased to receive from Engineers fully experienced in al design of petroleum or chemical

ful candidate should have a good Mechanical Engineering, combined perience of the industry. **NCING SALARY UP TO £2750**

te fullest particulars of previous which will be treated in the strictest the Managing Director. E6495, " The Engineer." A

SOILS ENGINEER
portunity for suitably qualified Civil ike leading position in new develop- of the principal U.K. building and g contractors operating both at home

ledge of theoretical soil mechanics and rience in site investigation methods and techniques and their application to constructional problems essential. alary and excellent prospects. Con- ion scheme. London area. ting, giving full particulars of training perience, to BOX No. E6439, " The A

ANT SUPERINTENDENT wanted owned 12,500kW. public utility in British Guiana. Age 30–40, family H.N.C. or, failing that, O.N.C., od experience with oil-fired boilers and essential. Salary equivalent of £1680 ree passages both ways ; three months' of three-year period ; interim local with electric cooker and refrigerator minal rental.—Applications, in writing qualifications, to Messrs. Mackness arliament Mansions, Abbey Orchard n, S.W.1, who will provide full par- interview. E6434 A

SITUATIONS VACANT

SPERRY
Bracknell Division,
DESIGN AND DEVELOPMENT ENGINEERS AND ASSISTANTS

We are seeking a few able and experienced TRANSISTOR - ELECTRONIC, ELECTRO - MECHANICAL and MECHANICAL ENGINEERS and ASSISTANTS to join our new premises in the New Town of Bracknell, where housing is available to selected applicants, especially from the greater London area.

These posts are at a senior and intermediate level within an established team tackling very advanced problems in guided weapon control, and the standards and rewards are high.

Applicants with an Honours Degree or equivalent or National Certificates for Assistants who have already demonstrated their ability, preferably in the servo field, are invited to write to the Personnel Manager (ref. E 387).

SPERRY GYROSCOPE CO., LTD.,
DOWNSHIRE WAY,
BRACKNELL, BERKS.
E6386 A

TECHNICAL SALES REPRESENTATIVE required, for South-Eastern Counties. Mainly concerned with the " Airhydropump." Knowledge of hydraulics and control of high pressures useful. Good salary (no commission) and car provided. Pension scheme.—Charles S. Madan and Co., Ltd., Vortex Works, Altrincham. E1697 A

THE BRITISH STEEL PILING CO., LTD., require a CIVIL ENGINEERING ASSISTANT, aged about 25 to 30, for their London office. The work will involve the design of steel sheet pile retaining walls for all types of civil engineering structures, as well as cofferdams and bearing pile foundations. An Engineering Degree or equivalent qualifications are required. Previous experience of steel piling and soil mechanics is not essential, though desirable.—Apply in writing only, giving details of qualifications and experience, and stating age and salary required, to the company at 10, Haymarket, S.W.1, marking the envelope " Engineering Assistant." E1681 A

THE GLACIER METAL COMPANY, LIMITED has two vacancies for WORK STUDY ENGINEERS.

The Work Study Engineers will be expected to make their own approach to problems presented to them, to devise and propose a solution and help to put it into operation. Typical projects involve examination of work flow, layout planning, materials handling, evaluation of machine design and use, &c. The emphasis is on study of methods—time study being dealt with by a separate group in the company.

1. The first vacancy is subordinate to the Chie Work Study Engineer at our factory in London. A man is sought at least 26 years old, preferably already with industrial work study experience, together with a recognised qualification in engineering, economics, accounting or statistics.

2. The second vacancy is for a man who would initially be responsible to the Chief Production Engineer of Service Group and carry out a tour of duties in three Service Stations of the company, situated in Manchester, Glasgow and London. At the end of this time, which would be at least a year and during which he would spend some six months away from London, he would join an established team either at the Scottish or London Factory of the company, according to mutual agreement at the time of engagement. He should be at least 28 years old and have several years' Work Study experience.

Application for either of these vacancies, both of which carry a SALARY RANGE of £850 to £1250 per annum, should be addressed to the Personnel Director, Glacier Metal Co., Ltd., Ealing Road, Alperton, Wembley, Middlesex. E6483 A

TRANSFORMER DESIGN ENGINEER
Applications are invited to fill vacancies in the Distribution Group of the Transformer Design Department of Bruce Peebles and Co., Ltd., Edinburgh, 5. Salary commensurate with qualifications and experience. Superannuation and production bonus schemes ; 5-day week.—Apply to Chief Transformer Designer. E6462 A

WANTED, ASSISTANT PLANT ENGINEER, age 23–35, for North East Coast. Experience of works services and extensions. Must have served good mechanical apprenticeship and have drawing-office experience. Interesting and varied work, with prospects of advancement. Apply.—BOX No. E6491, " The Engineer." A

SITUATIONS VACANT

DRAUGHTSMEN

Manufacturers of Pumps, including Pumps for Chemical and Oil Industries, have vacancies for Designers and Draughtsmen.

Apply, giving full details of previous and present employment, Technical training, age, etc., in strict confidence to the Assistant Managing Director (Admin.), Tangyes, Limited, Cornwall Works, Smethwick, Birmingham.

E6485 A

C. A. Parsons & Co. Ltd.

NEWCASTLE-UPON-TYNE

CHIEF METALLURGIST

SENIOR RESEARCH METALLURGISTS

RESEARCH METALLURGISTS

SENIOR METALLOGRAPHER

ASSISTANT METALLOGRAPHERS

Applications are invited for these appointments in a **NUCLEAR RESEARCH CENTRE** now being established on a new site in Newcastle-upon-Tyne, to provide the most up-to-date research and development facilities to meet the present and long-term needs of **THE NUCLEAR POWER PLANT CO., LTD.** The Metallurgical Laboratories are being planned to cover all aspects of nuclear fuels, canning materials and reactor steels. Special interest relates to Powder Metallurgy, Ceramics, Cermets, Zirconium, Magnesium, Niobium, &c., including methods of fabrication oxidation, compatibility and behaviour under irradiation

THE CHIEF METALLURGIST will be responsible for the planning and equipping of the new laboratories and on their completion will take charge of them with full responsibility for the initiation and supervision of research in his department.

He should have the highest technical qualifications and should have held a responsible position in a research organisation preferably one devoted to nuclear work.

SENIOR METALLURGISTS.—Graduates, preferably with an Honours Degree and with research experience, who can take charge of a section or sections of the work of the department. They will be responsible to the Chief Metallurgist, but will have the maximum freedom consistent with departmental policy in directing the work for which they are given responsibility. Previous experience directly applicable to the scope of the work outlined is desirable, but not essential.

RESEARCH METALLURGISTS.—The work to be undertaken at the Research Centre and the facilities provided offer unique opportunities to metallurgists who wish to enter this new and expanding field. Applications will be welcomed from graduates with some years' research experience or from those completing their studies this year. Salaries will be in accordance with experience and ability to take responsibility.

SENIOR METALLOGRAPHER.—A metallographic department, complete with the latest equipment will serve the research centre. The Metallographer in charge is responsible to the Chief Metallurgist for ensuring that his department is staffed and equipped to provide a high-class service. This position is considered a most important one and only fully qualified men with considerable experience should apply.

ASSISTANT METALLOGRAPHERS.—The work in the Metallography Department covers a wide field of considerable interest and applications will be welcomed from technically qualified men or women.

GENERAL

The appointments are pensionable and successful applicants will be entitled to participate in the Company's Superannuation Scheme. Assistance with regard to housing can be provided where necessary. Since the Research Centre is only in the process of building, some latitude is possible as to the time at which an appointment —other than that of the Chief Metallurgist—is taken up.

Applications, giving full particulars of training, qualifications, experience and positions held, should be sent to The Research Director, C. A. Parsons and Co., Ltd., Heaton Works, Newcastle-upon-Tyne, 6. If it is desired that the application be treated confidentially, it should be so marked. Further information will be gladly supplied on request.

E6369 A

BOOKS and PUBLICATIONS

RELATING TO BUILDING
EERING CONTRACTS
W. T. CRESWELL, K.C. Sixth
D. R. PERREY, B.A. (Hons.)
itor. A completely revised
edition of this well-known
porates the 1939 (revised 1956)
dard Form of Building
net.

TURAL ENGINEER'S DATA
RESWELL, A.M.I.Struct.E. etc.,
G. KING, A.M.I.C.E., etc.

An indispensable handbook for all those connected with structural design. Specially devised for easy and quick reference, it is packed with up-to-date facts and figures that are constantly needed in the course of a day's work. 35/- net.

FLUID PRESSURE MECHANISMS
By H. G. CONWAY, M.A., etc. 2nd Edition. This book deals with hydraulic and pneumatic machinery. It is not concerned with detailed design or constructional features, but with the essential principle of the various devices, how they work and how they differ from each other. 32/6 net.

PITMAN Sir Isaac Pitman & Sons Ltd.

PARKER ST., KINGSWAY, LONDON, W.C.2.

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SITUATIONS VACANT

AN UNUSUAL OPPORTUNITY

A QUALIFIED MECHANICAL ENGINEER, age 28–35, preferably with some knowledge of diesel engines who wishes to make a career on the commercial side of industry, is offered an exceptional opportunity with an old-established, progressive, medium-sized engineering company in London. After training he will be appointed to the position of Export Sales Manager and ultimately General Sales Manager. It is essential that he should have been to a Public School, have outstanding personality and drive, be able to negotiate successfully with top executives, and also have administrative ability. Commencing salary up to £1500 and pension.—Please write, giving details of age, education, positions held and salaries, to BOX No. E1696, "The Engineer." A

SITUATIONS VACANT

WILLIAM DOXFORD & SONS (ENGINEERS) LTD. SUNDERLAND

Invite applications from

SENIOR DRAUGHTSMEN

with experience of the Doxford Heavy Marine Oil Engine for positions in their Design Department. The work is varied and interesting, with good prospects, with salaries according to ability and experience. Pension scheme in operation. Interviews can be arranged to suit the convenience of applicants.

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E6479 A

SITUATIONS VACANT

ENGINEERS FOR MANAGEMENT

- Applications are invited from men aged 30–35, with either a Mechanical Engineering Degree or A.M.I.Mech.E., whose experience has included contact with some form of industrial process work, either in a supervisory or technical capacity.
- The main qualities sought in candidates are adaptability, a keen brain and the ability to organise and weld groups of technicians, shop supervisors and operators into a highly efficient team.
- If you think this may be the opportunity you are seeking, do not let possible housing problems deter you.
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Please write to (Mr.) A. C. McCombie c/o

MICHELIN TYRE CO. LTD.,

STOKE-ON-TRENT

quoting reference TS.3/E.

E6480

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Kellogg's design capacity increased substantially in 1956 compared with 1955. In 1957 it was more than double that of 1955. This indicates that we offer the oil and chemical industries *something* to account for these increases in the volume of our work and in the size of our staff to handle it. That "something" is greater process know-how, more solid design experience, speed and efficiency, and a record of achievement in our business of which we are proud. If you are qualified you can join our team. Our knowledge and our high standards of engineering work will then help in your own development!

Our Piping Designer/Draughtsmen are of a high standard and we therefore can consider only men of equal calibre.

Our permanent staff benefit from above-average salaries, liberal personnel benefits, good working conditions, excellent Social Club, etc.

If you qualify and are interested you are invited to write to, or telephone the PERSONNEL MANAGER :—

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INTERNATIONAL CORPORATION

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E6433 A

HEAD WRIGHTSON

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Ever Expanding Commitments in the Fields of

NUCLEAR POWER · IRON-MAKING
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CHEMICAL ENGINEERING
GENERAL MECHANICAL ENGINEERING

Call for a variety of experimental programmes and constant growth of their

RESEARCH AND DEVELOPMENT DEPARTMENT

Applications are invited from Graduate

CHEMICAL ENGINEERS · PHYSICAL METALLURGISTS
EXTRACTION METALLURGISTS · MATHEMATICIANS

MECHANICAL ENGINEERS also required for design and development of new projects from design pad to pilot plant and prototype.

The atmosphere is stimulating—and at times unorthodox.

Write giving full details of training and experience to:—
Personnel Manager, Ref. RD/EG/13,
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THORNABY-ON-TEES.

E6478 A

ICI

GENERAL CHEMICALS DIVISION

Vacancies for

Mechanical or Electrical Engineers

in its

POWER DEPARTMENT

The Division is one of the largest private users of steam and electrical energy in this country and its activities in these fields cover a wide range in a number of areas and include, on a very extensive scale, Industrial Power Stations, High-Voltage Electrical Distribution Systems, Main Substations, A.C./D.C. Convertor Substations, D.C. Distribution Systems, Works Medium Voltage A.C. Distribution Systems, Works Electrical Equipment, Steam Distribution Systems and Lancashire and Economic Boilers.

The Power Department is responsible for design, installation, operation and maintenance in connection with all these activities.

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In addition, there are vacancies for men graduating this year for whom GRADUATE APPRENTICESHIPS will be available.

There are excellent conditions of service and prospects, pension and profit-sharing schemes and for married men assistance is given towards removal expenses and legal charges incurred in house purchase.

Applicants should write, quoting reference MEPD21, to :

STAFF MANAGER, IMPERIAL CHEMICAL INDUSTRIES, LTD.,
GENERAL CHEMICALS DIVISION, CUNARD BUILDING, LIVERPOOL 3

B6

GRESHAM TRANSFORMERS LT

Hanworth, Middlesex

CHIEF ENGINEER

An Engineer with Degree and/or Membership of the I.E.E., required to control and develop the design function of the Company, including the drawing office, covering all types of transformers up to 10mVA. This Company is at present extending its overseas markets and is prepared to give considerable scope for expansion to the Chief Engineer's department.

Age group—30 to 40 years. Applications to the Technical Director.

E7

SITUATIONS VACANT

...RKS ENGINEER

... NORTH BRITISH STEEL ...Y, LTD., invite applications for ... of Works Engineer.

...ition is an executive one and ... all-round experience in mecha... electrical engineering, building and ...tenance work, and the organisa... control of labour.

... will be commensurate with the ...ity involved, and there is a pension ... A company house is available.

...ion, giving full details of educa...rience, qualifications, and present ...ould be made to :

...retary,
...North British Steel Foundry, Ltd.,
...ide Steel Works,
... West Lothian.

E6431 A

SHELL PETROLEUM COMPANY LIMITED

... a vacancy for a young

...VIL ENGINEER

... with work on the applications of ... This involves the study of a wide ...ractical problems in road and civil ... through Shell Group's world... ...ities. It will appeal to those men ...erly the findings of research to the ... of new uses and improved appli... industry.

...ates should preferably hold either ... Civil Engineering Degree or ...—age not exceeding 32 years. ...ary offered will be commensurate ...ience and qualifications.

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... DEPARTMENT (R)/CE., ... SHELL PETROLEUM ...OMPANY, LIMITED, ... HELEN'S COURT, ...REAT ST. HELEN'S, ... LONDON, E.C.3.

E6382 A

...ECHANICAL ...ENGINEER

... Chief Designer for an enterpris... ...ubstantial engineering company. ...intment offers excellent prospects ...ical engineer used to designing ...with moving parts and with the ... direct a design staff and to work ...Sales and Production Executives. ...any depends for its future on the ...revision of existing designs and ...ent of new ones and is prepared to ...stantial salary to the right man.

...ions, which will be treated in ...idence, should be addressed to ... Orr and Partners, Limited, 29, ...Street, London, W.1, quoting refer... ...236 on the envelope.

E6429 A

...UATIONS WANTED

...ENCED WORKS MAINTEN...NEER available shortly. Experience ... plant (high efficiency), all services, ..., sewage, vacuum and compressed air, ...allation and planned maintenance. ...nd in installation and erection of food ...plant and buildings, including flame... ...able to control drawing-office and ...—BOX No. E1703, "The Engineer."
B

...MANAGER (age 44), desires change. ...e hot and cold strip mills, ancilliary ...development, expansion programmes, ...el.—BOX No. E1722, "The Engi...
B

...UALIFIED ENGINEER (M.Sc., ... years' one firm, 16 years' another, ... closure of works. Bit long in tooth ...er but capable of handling contracts, ...plant layout, including drawing or ...elopment work on a free lance basis, ...or North London.—BOX No. ...gineer."
B

... HYDRAULIC ENGINEER.—... (33), wide experience as Technical ...draulic engineering concern, seeks ...e post.—BOX No. E1723, "The ...
B

SITUATIONS WANTED

MANAGER-EX-CHIEF ENGINEER of Cement Factory in Far East, would be interested in a Managerial or Senior Engineering post in Mining, Cement, Irrigation or General Engineering Manufacture. Post in Africa, South America, Mexico or Colonies preferred. Europe not considered. Private companies preferred, but State projects considered if permanent. The applicant is a fully qualified and experienced Manager and Engineer, familiar with machine design, civil and mechanical engineering, land acquisition, accounts, incentive schemes, personnel management, office organisation and drawing-office organisation. Present salary equivalent to £3000 per annum. Highest possible references and particulars will be sent to reliable firms genuinely interested in permanent services. Reason for wanting change is mistrust of political future locally.—BOX No. E1721, "The Engineer." B

MECHANICAL ENGINEER, B.Sc. (Hons.) A.M.I.Mech.E., (33), Process Plant Engineer experienced in special purpose machinery design and development, seeks change. Present salary £1350.—BOX No. E1718, "The Engineer." B

NUCLEAR/MECHANICAL ENGINEER, B.Sc. (Phys., Chem. and Math.), B.Sc. Engg. (Mech.), and also attended the Harwell Reactor School course (16 week), with broad engineering and scientific background specially in the fields of thermodynamics, heat transfer, lubrication and bearings, machine design, photo-elasticity and coloured photography, nuclear engineering, &c. Good knowledge of German. Seeks a position in Research or Project or Design of Nuclear Power Plants.—BOX No. E1702, "The Engineer." B

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A FULLY EXPERIENCED TRACER will undertake to prepare tracings of any kind of drawings on paper or linen.—BOX No. E1719, "The Engineer." S

DRAWING AND DESIGN SERVICE.—Design and Development work required (London), for chemical and industrial plant equipment, special purpose machines, jigs and tools.—BOX No. E1720, "The Engineer." S

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CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process; sample castings treated; A.I.D. approved.—Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E575 MW

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PRECISION MACHINING CAPACITY Centre Lathe, Capstan, Milling, Shaping, Drilling, Tapping, Assembling, Jigs, Fixtures and Press Tools. A.I.D. and A.R.B. Approved.
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BLACKHEART MALLEABLE IRON CASTINGS
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AGENCY REQUIRED for a West country and Welsh Branch centred at Gloucester. Selling Engineering Material, Material Handling, Light and Heavy Industrial Plant. Write.—BOX No. E6448, "The Engineer." D

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PIPE FITTINGS.—Agent seeks company manufacturing Valves and/or Flanges, &c., who would be interested in ACTIVE REPRESENTATION in the London area.—Reply, BOX No. E1676, "The Engineer." D

BUSINESS OPPORTUNITIES

COMPANY CONTEMPLATING CIGARETTE LIGHTER MANUFACTURE would like supplier of necessary plant and equipment to contact.—BOX No. E1712, "The Engineer." O

HIGHLY REPUTABLE ENGINEERING FIRM, old established, and contractors to H.M. Government, have capacity available for, preferably, complete Manufacture of Additional Line, or, alternatively, Sub-Contract Work involving Grey Iron Castings up to 1 ton weight. Own pattern, foundry, machining and assembly shops. Manufacture under licence or royalty considered.—BOX No. E1591, "The Engineer." O

LANCASHIRE ENGINEERING DIRECTOR, retiring April, contemplating visit to Canada, would undertake Negotiations for Engineering Firms.—BOX No. E1699, "The Engineer." O

VALVES.—Engineers with capital willing to Purchase Controlling Interest in Company manufacturing Valves. Replies will be treated in strictest confidence. —BOX No. E1666, "The Engineer." O

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PATENTS

THE PROPRIETORS of Patent No. 707,266, "IMPROVEMENTS IN OR RELATING TO ELECTROSTATIC PRECIPITATORS," are prepared to enter into negotiations for the commercial development of the invention by LICENCE or otherwise.—Replies to HULSE & CO., 269, Glossop Road, Sheffield, 10. E1716 H

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LATTICE STEEL Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1 ('Phone, SLOane 5259). E112 K

MISCELLANEOUS

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TIME RECORDERS, Sales, Rentals, Service, Telephone Hop 2239.—Time Recorder Supply and Maintenance Co., Ltd., 157–159, Borough High Street, London, S.E.1. E608 I

MACHINERY Etc. WANTED

SECOND-HAND SCREWING MACHINE fitted with tangential diehead, capacity 1¼in. Whitworth bolts. Must be modern.—BOX No. E6437, "The Engineer." F

WANTED—BOILERS

John Thompson BETA Water Tube Boiler, evaporation 45/50,000 lb. per hour, 250/300 lb. working pressure.—BOX No. E6501, "The Engineer." F

WANTED, Machines of all Types.
CASH PAID.
Norman E. Potts (B'ham), Ltd., 130, Moseley Road, Birmingham 12. VIC. 1278 1279 1270, 0856. E123 F

WANTED, Tube Expanding Machine, Tube Cleaning Machine, 6in. to 8in. Screwing Machine, with collapsible head.—Fred Watkins (Boilers), Ltd., Coleford, Glos. E997 F

FOR SALE

20-TON STEAM LOCOMOTIVE CRANE
For Sale
By Brownhoist, 20 U.S. tons, 2 hoist drums, 50ft. jib, high-speed double bogie truck, screw couplers, air brakes, spring buffers. To British rail and loading gauge. Brand new, cased as despatched from makers.
L. NELSON & CO., LTD.,
LUGTROUT LANE, SOLIHULL, WARWICKS.
Tel.: Sheldon 4005. Tel: Sheldon 4443. E1714 G

UNUSED SET OF PLATE BENDING ROLLS, capacity 32ft. by 1in. down to 6ft. by 2½in. mild steel plate; 75 h.p. roll drive, 40 h.p. screw-down; electrics 400/3/50.—BOX No. E6389, "The Engineer." G

FOR SALE.—2 Yale Pallet Trucks, £15 each or offer.—Write, 0533, Wm. Porteous and Co., Glasgow. E6464 G

FOR SALE

STEAM LOCOMOTIVES FOR SALE

Item	Bore and stroke	Type and make	When built	Working pressure, p.s.i.	Net weight, tons
1.	14×22	040 Barclay	—	160	22
2.	14×22	040 Barclay	—	160	22
3.	14×22	040 Barclay	—	160	22
4.	14×22	040 Barclay	—	160	22
5.	14×22	040 Barclay	1935	160	22
6.	17×24	040 Barclay	1934	160	36
7.	17×24	040 Bagnall	1940	160	36
8.	17×24	040 Bagnall	1941	160	36
9.	17×24	040 Bagnall	1941	160	36
10.	17×24	040 Bagnall	1944	160	36
11.	18×26	060 Bagnall	1950	180	40½

All the above being recently in service and well-maintained. Insurance reports available.

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BRIDGEND, GLAMORGAN
(TELEPHONE: BRIDGEND 1311/2/3.)
E986 G

TWW

NEW MASSEY 2 cwt. CAPACITY CLEAR SPACE TYPE PNEUMATIC POWER HAMMER, stroke 14in., ram pallet face 5¼in. by 4¼in., anvil pallet face from floor 26in., dia. of ram 7¾in., approx. 200 blows per minute; arranged for vee belt drive.
MASSEY 7 cwt. CAPACITY GUIDED TYPE PNEUMATIC POWER HAMMER, stroke 24in., ram pallet face 11in. by 7in., anvil pallet face from floor 24in., overhang 19¼in., arranged for vee belt drive and complete with NEW motor and Star Delta starter suitable for 400/3/50.
MASSEY DOVETAIL TYPE ANVIL BLOCK, in very good condition, having had little use, suitable for modern 15 cwt. friction drop stamp.
FRASER MONI-RADIAL HYDRAULIC PUMPING SET, type 00F30DZ, 30 g.p.m. at 3300 p.s.i., direct coupled to Brush 75 h.p. slipring motor running at 720 r.p.m., wound suitable for 400/3/50, all mounted on common baseplate.
HARLAND SINGLE-STAGE, HORIZONTAL, SPLIT-CASING, CENTRIFUGAL PUMPING SET, type SDA/12/14, 14in. suction and 12in. delivery branches, capacity 3500 g.p.m. against 43ft. head, direct coupled to 70 h.p. Harland squirrel-cage motor and complete with floor mounting auto-transformer starter, wound suitable for 400/3/50.
ALL THE ABOVE MACHINES AVAILABLE FOR IMMEDIATE DELIVERY FROM STOCK, SUBJECT TO REMAINING UNSOLD.

THOS. W. WARD LTD.
ALBION WORKS - - - SHEFFIELD.
'Phone: 26311. 'Grams: "Forward."
E214 G

Edwards

SEDGWICK 200 tons, Double-Geared Press Brake, capacity 12ft. by ¼in., arranged motor drive 400/3/50, depth of gap 18in., stroke 3in.; die space, top tool to bed, stroke down, bed adjustment in lowest position 4¾in., between side frames 83in. Weight about 15 tons.
BESCO Size R150/10 All-Steel Press Brake, capacity 150 tons, 10ft. wide by 3/16in. thick, between housings 10ft., overall length of dies 138in., depth of gap 12in., length of stroke 3in., arranged motor drive 380/420/3/50. Weight about 16½ tons.
QUICKWORK No. 321 Motorised Rotary Shearing Machine, with circle cutting attachment, capacity 14 S.W.G. mild steel, depth of shear throat 30in., cuts circles from 6in. to 60in. diameter, diameter of cutters on inclined shafts 2in., arranged motor drive 400/440/3/50.
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BESCO Double-Geared, Hand-Operated, Universal, Swing Beam Folding Machine, capacity 6ft. 2in. by ¼in. thick, lift of clamping beam 8in., adjustable folding centres, smallest trunk formed round the beam and withdrawn 8¾in. by 7¾in.
SELSON Rapid Flanging Machine, for flanging straight or curved edges, maximum thickness ¼in., maximum depth of flange 1½in., arranged motor drive 400/3/50.
Photographs of the above are available.

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All kinds of Hydraulic Equipment in stock.
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Cuba Street, Millwall, London, E.14.
East 1844/5.
E629 G

Classified Advts. continued on page 140

FOR SALE

600

STEAM TURBO-ALTERNATOR SETS

3000kW., 6600/3/50, MET.-VICK., Pass-out/Condensing Steam Turbo-Alternator Set, date 1948, designed for 340 p.s.i.g initially, 600 deg. Fah. temperature; also suitable for the following duties:

Output/kW.	Pass-out/lb./hour	Lb. Pressure
3000	60,000	40
1800	40,000	110
1800	40,000	

double Pass/out at 1000kW., fully condensing.

2500kW., 440/3/50, B.T.H., speed 3000 r.p.m., 250 p.s.i.g., 630 deg. F., steam consumption approx. 12·8 lb./kW./hr., with surface condenser, circulating pumps, &c. Also suitable for pass-out pressures varying between 18/35 p.s.i.

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Tel.: Shepherds Bush 2070; and
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MILLING MACHINES

CINCINNATI No. O–8 Automatic Horizontal MILLING MACHINES with rise and fall spindle carrier and automatic table feeds cycle. Table 18½in. by 6½in.

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EUSton 4681 and 3771. E6458 G

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Motor and gearbox available separately if required.

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Tel.: Newport 66941 (6 lines).
E991 G

FOR SALE.—Hall Harding Verax Photo Copier, double-sided feed, 12ft./min. Also No. 4 Photostat Camera, 24in. by 18in., complete with 4 lights and auxiliary equipment. All the above in perfect working condition.—Telephone Chief Draughtsman, EALing 0011, for appointment to view. E6515 G

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TWO NEARLY NEW POWERFUL CRANES

90-ton Electric Travelling Goliath Crane, 106ft. span, 72ft. lift, all lattice steel construction, electrics 400 volts, 3-phase, 50 cycles. Tested by Lloyds to 150 tons.

35-ton Electric Portal Wharf Crane, built 1945; 35 tons at 60ft. fixed radius, 85ft. height of lift, rail gauge 40ft. admitting 3 lines of standard gauge track, electrics 440/3/50, with Ward-Leonard generator.

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Replant Works, Woolwich Industrial Estate,
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Telephone: Woolwich 7611/6.
E6390 G

HYDRAULIC PRESSES

Large stock of modern Presses up to 10,000 tons capacity, for Forging, Forming, Extruding, Baling and other duties.

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SCRIVEN BAR BREAKING MACHINE

Single ended, double acting, to break billets 6in. square, 40 tons tensile, motorised with starter for 400/3/50.—Details and location from NORMAC, LTD., Pepper Road, Leeds, 10. Tel.: 77779. E992 G

TWW

LARGE STOCK OF 3, 5, 8, 10-TON CAP. HAND-OPERATED WIRE ROPE CRAB WINCHES for disposal.
Price and particulars, apply:

THOS. W. WARD LTD.
ALBION WORKS - - - - SHEFFIELD
Tel.: 26311. Ext. 305. E215 G

FOR SALE

10-ton capacity Morris 3-motor, cab-controlled, twin girder, Overhead Electric Travelling Crane, 47ft. span, 440/500V. D.C.
6-ton Morris Ditto Crane, 40ft. span.
2-ton Morris Ditto Crane, 28ft. 6in. span, pendant control, 400/3/50.
10-ton Brand New Morris, 2-motor, O.E.T. Crane Crab, totally enclosed gearing, 440/500V. D.C.

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SECTIONAL TANK, 48ft. by 48ft. by 12ft. deep with division plate and top cover, capacity 165,000 gallons. Mounted on 40ft. tower. Available ex-site immediately. We can dismantle and re-erect.—Fred Watkins (Boilers), Ltd., Coleford, Glos. E6494 G

NEW COLCHESTER "MASCOT" S.S. an S.C. Gap Bed LATHE. 8½in. H.C. by 54in. B.C. Price £898. Delivery immediately ex our London stock.—Welling and Welling, Ltd., 4, Victoria Street, London, S.W.1 (Tel.: ABBey 2341). E989 G

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½ cu. yd. Chaseside Hi-Lift cable-operated Loading Shovel. New 1953.
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Several 15 cwt. Liner "Roughrider" diesel-driven Dumpers.
Several 3in. diesel-driven Search "Mud Marvel" diaphragm lift and force Pumps.
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SEARCH (LIVERPOOL), LIMITED,
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E6442 G

C·E·M

"BENTLEY" Plate Bending Rolls rom 6ft. by ¼in. up to 10ft. by 1in. m.s. capacities. Opening end frame for withdrawing rolled cylinders, self-supporting top roll, finger-tip control, all rolls of generous dia. from solid forged steel, full electrical equipment. Very moderate prices. Early deliveries.

"SEDGWICK" Universal Plate Bending and Folding Machine, 6ft. by ¼in.

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E994 G

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ROSS. 6,000—14,000 lbs. Diesel
120" to 210" lifts. Pneumatic tyres.
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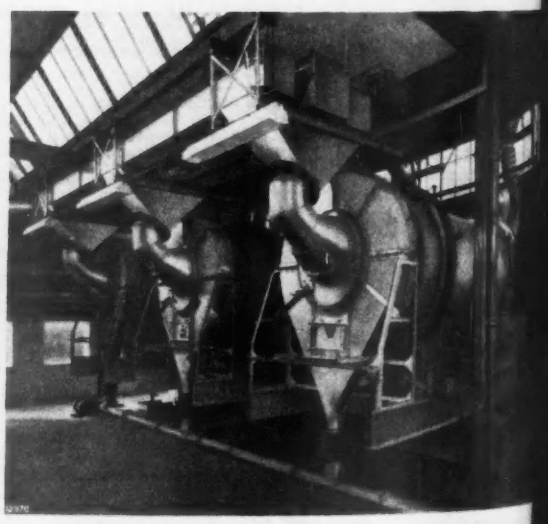

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On the left, is shown a laboratory Rotary Dryer, and the illustration above, is of a group of Sturtevant Rotary Dryers treating an expensive material which is most difficult to dry and handle. They operate on an automatic sequence of batch drying and any one of the dryers can be supplied with three different air conditions.

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March 18–21 & 24–28	Vehicles, earth moving equipment, cranes, trailers, tractors, motor cycles, etc.	M.O.S. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), 8yard Lane, Bridleasmith Gate, Nottingham. (Tel.: 47271.)
March 26	Miscellaneous stores, including tentage, clothing, blankets, furniture, etc.	Northern Command Ordnance Sub-Depot, Barlow, Nr. Selby, Yorkshire	BARTLE & SON (Dept. L), 30–32, Merrion Street, Leeds, 2. (Tel.: 2–0898.)
April 1–2	Machine tools and miscellaneous stores, including :—	M.O.S. Sub-Depot, Lily Lane, Byley, Middlewich, Cheshire. (Sale at New Islington Public Halls, Ancoats, Manchester.)	J. H. NORRIS & SON (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
	nylon and drill overalls, B. D. blouses, shirts, underpants, pullovers, galoshes, scrap canvas, blankets, valises, webbing, centre, capstan and turret lathes, Churchill automatic, grinding machines, universal milling machines, radial drill, boring machine, presses, cold saws, electrical equipment, M.T. spares, Rolls Royce engines, railway wagons, trailer-mounted crane, roller conveyor, cable and wire, aluminium bar, pumps, pipes, bends and tees, stocks and dies, hand tools, canteen equipment, furniture, telescopes, paint, chemicals, etc.		
April 15–17	Machine tools, miscellaneous stores, vehicles, batteries, etc.	M.O.S. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18	FULLER, HORSEY, SONS & CASSELL (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)

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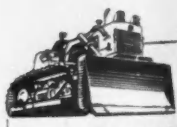

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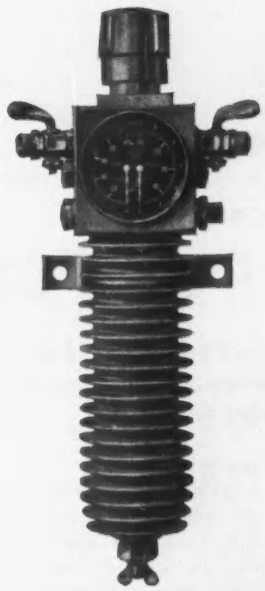

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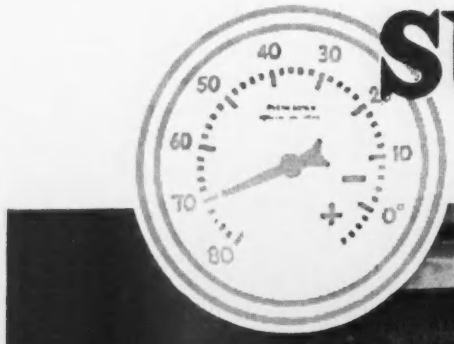

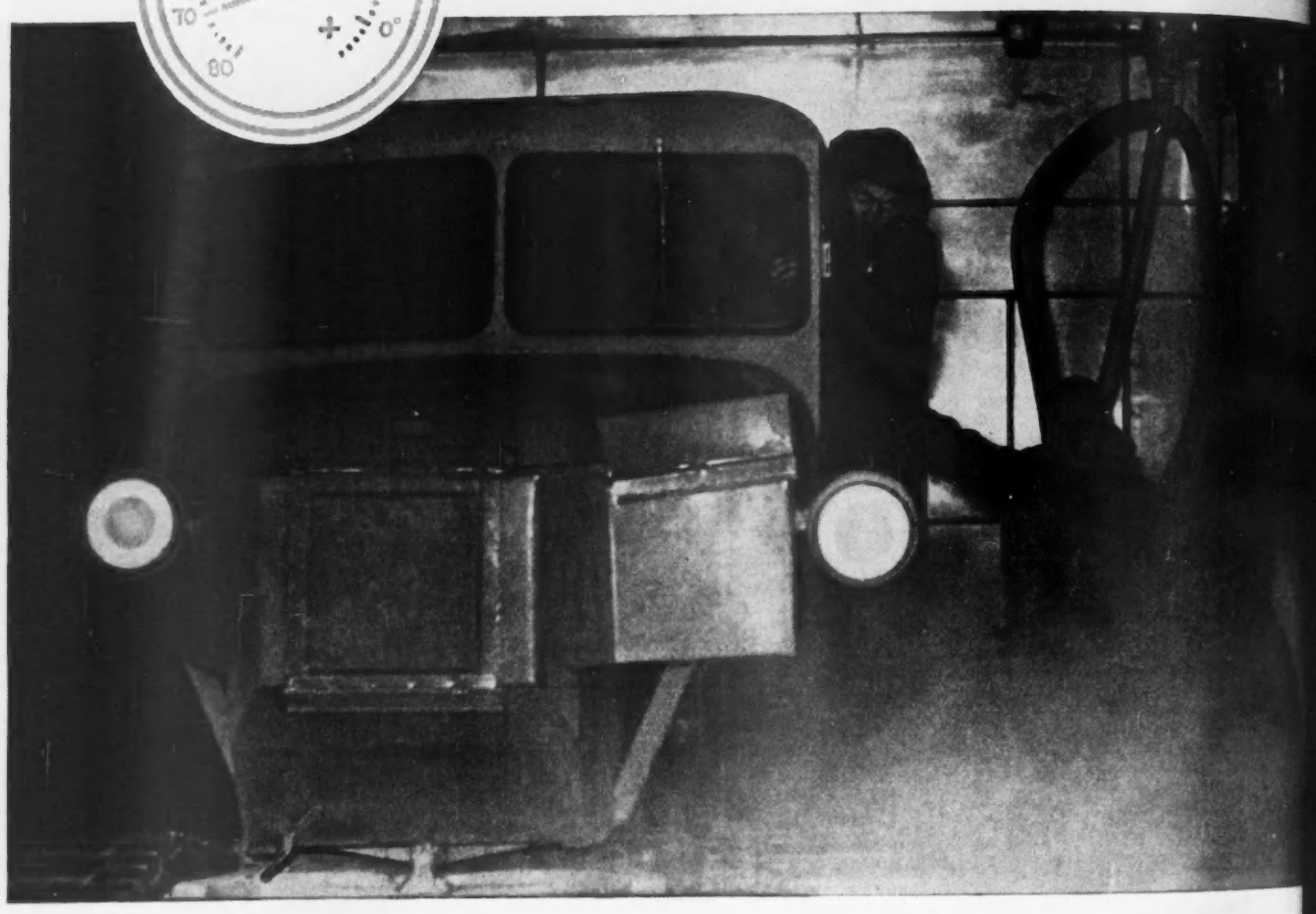

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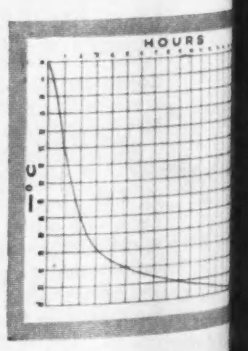

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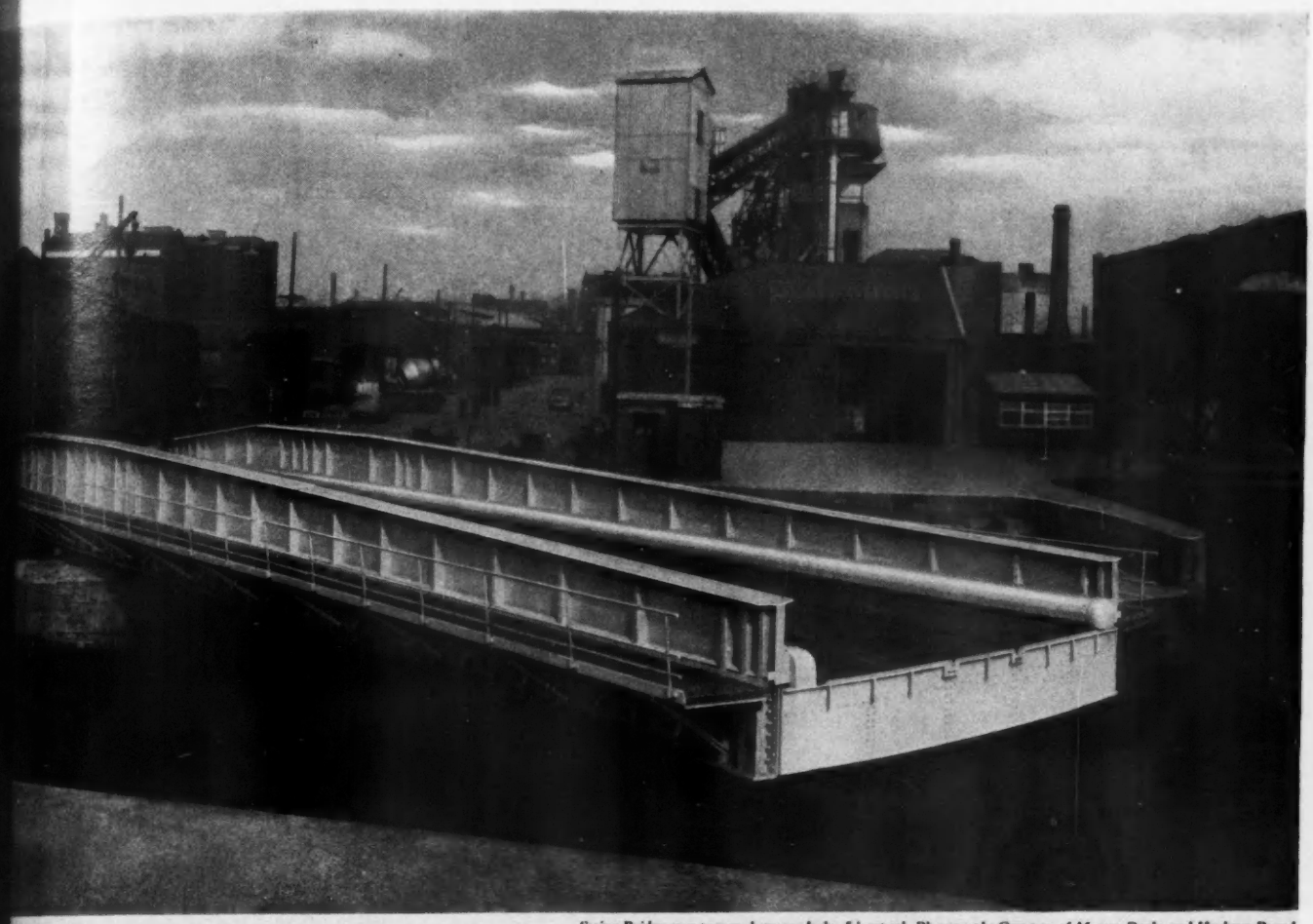

Swing Bridge over passage between docks, Liverpool. Photograph: Courtesy of Mersey Docks and Harbour Board.

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